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(54) **METHOD AND APPARATUS FOR MEASURING COATING**

VERFAHREN UND VORRICHTUNG ZUR MESSUNG EINER BESCHICHTUNG

PROCÉDÉ ET APPAREIL POUR MESURER UN REVÊTEMENT

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Description

FIELD OF THE INVENTION

[0001] The invention relates to measuring a paper or board coating. Particularly the invention relates to measuring the coating by means of IR radiation.

BACKGROUND OF THE INVENTION

[0002] Measuring a paper or board coating is an important part of the manufacturing process of paper or board, because an appropriate coating improves, for example, printability, gloss and colour of paper. Instead of applying only one coating layer, the coating can be performed several times using several different materials. Coating materials include binders and coating pigments, and some of the coating components that are used include kaolin, calcium carbonate, talc, gypsum, latex, starch, many synthetic binders and special coatings, such as silicon.

[0003] A prior art coating system is described in US Patent 5795394. This coating system concentrates on measuring calcium carbonate and controlling the coating in the MIR region. In the solution of the publication, MIR radiation is directed at a coated substrate at two separate wavelength bands, one of which is sensitive to the substrate and the other is sensitive both to the substrate and to calcium carbonate. On the basis of these different wavelength band strengths, the amount of calcium carbonate is measured, and the amount of coating is adjusted by means of the measured calcium carbonate. As far as measurements of other components are concerned, the publication mentions the measurement of kaolin, and also the measurement of paper moisture. The problem of the solution given in the publication is that the amount of only a few components (mainly that of calcium carbonate) used in the coating can be measured, although a large number of coating materials can be used for coating paper or board. Since several detectors are used in the measurement, the used equipment is complicated and expensive. Another disadvantage of using several detectors is that the measurements are inaccurate, which is due to nonidealities in the optical path used by the detectors, which means that each detector sees the optics in a different manner. In addition, the strength of the signal to be detected weakens in proportion to the amount of components or detectors.

[0004] Another prior art solution to measure a coating is described in US Patent 5338361. In the solution according to the publication, components of two different coatings on the substrate are measured by using three separate NIR wavelength bands, the first wavelength band being sensitive to the first component, the second wavelength band to the second component and the third wavelength band to the substrate. In order to measure several different coatings more wavelength bands are used. Since this solution, too, employs several detectors in the measurement, the used equipment is complicated and expensive. A further disadvantage of using several detectors is that the measurements are inaccurate, which is due to nonidealities in the optical path used by the detectors, which means that each detector sees the optics in a different manner.

BRIEF DESCRIPTION OF THE INVENTION

[0005] It is an object of the invention to implement an improved method and an apparatus implementing the method.

[0006] This is achieved by a method for measuring a coating from paper or board by means of IR radiation according to claim 1, and an apparatus for measuring a coating from paper or board by means of IR radiation according to claim 16. Further features and advantageous modifications are shown in the dependent claims.

[0007] The method and system of the invention provide a plurality of advantages. As the amount of components to be detected increases, the amount of detectors does not. Furthermore, the strength of the radiation to be detected does not decrease in proportion to the amount of components to be detected or to the amount of detectors. Interferences, for their part, are efficiently eliminated by combining radiation chopping and filtering.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] In the following the invention will be described in greater detail by means of preferred embodiments and with reference to the attached drawings, in which

Figure 1A shows NIR radiation absorption of different components,
Figure 1B shows MIR radiation absorption of different components,
Figure 2A is a block diagram of an apparatus when one detector is used,
Figure 2B is a block diagram of an apparatus when two detectors are used,
Figure 3A is a structural view of the apparatus when one detector is used,
Figure 3B is a structural view of the apparatus when two detectors are used,
Figure 4 shows a chopper disc,
Figures 5A to 5F illustrate the timing of optical rays chopped with a chopper, and
Figure 6 shows how the apparatus can be applied to measuring coatings of a paper machine.

DETAILED DESCRIPTION OF THE INVENTION

[0009] The solution according to the invention is particularly applicable to measuring coating components of paper or board and measuring moisture of paper and board.

[0010] In this application, the NIR (Near IR) region of

IR (InfraRed) radiation refers to an electromagnetic spectrum band of 700 nm to 2500 nm. The MIR (Middle IR) region, for its part, refers to an electromagnetic spectrum band of 2500 nm to 20000 nm. These definitions correspond to the understanding of a person skilled in the art on NIR and MIR radiation.

[0011] In the inventive solution, one or more coating components, such as calcium carbonate, kaolin, silicon and water, are measured by using MIR radiation, and one or more components, such as kaolin, talc, gypsum, latex, starch, silicon and water, are measured by using NIR radiation. In the method, the moisture content is determined by measuring water.

[0012] To begin with, let us examine the background of Figures 1A and 1B. Absorption means the attenuation of radiation strength, which is measured by intensity, in a material to be measured. When the intensity I_0 of optical radiation propagates to an absorbing material, the radiation attenuates according to Bouguer law in the following manner:

$$I = I_0 \cdot e^{-\alpha x},$$

where I_0 is radiation intensity arriving at a material, x is the distance travelled by the radiation, I is the radiation intensity after the travelled distance x, α is the absorption coefficient and e is the base number of the natural logarithm. The amount of absorption as such is the product αx of the absorption coefficient and the distance travelled by the radiation. As the detector can directly measure only the strength of radiation, the strength of absorption is formed in a manner known per se by, for example, directly comparing the intensity I_0 directed to an object to be measured or the reference intensity in known proportion to it, and the intensity I measured by the detector:

$$\alpha x = -\log_e \frac{I}{I_0}.$$

[0013] Let us now take a closer look on the absorbancy of paper and board coatings as a function of wavelength by means of Figures 1A and 1B. In Figures 1A and 1B, the x-axis is the wavelength and the y-axis is the absorption strength. Figure 1A shows an absorption curve of board coated with kaolin in the NIR region. An absorption peak 100 at 1940 nm is caused by water, an absorption peak 102 at 2100 nm is caused by cellulose and an absorption peak 104 at 2208 nm is caused by kaolin. In the inventive solution the absorption strength of kaolin can be measured by NIR radiation at a wavelength band, the middle wavelength of which is at the point sensitive to absorption, i.e. at the maximum absorption point at a wavelength of about 2208 nm. During the measurement the object to be measured is illuminated with IR radiation and the radiation strength 104 of the wavelength band 106 is measured. To determine the strength of the absorption peak 104 caused by kaolin, the radiation strength is also measured at other points 108, 110 which are not sensitive to absorption. This measurement is performed at least from one side of point 106 sensitive to absorption, i.e. from point 108 or 110, the middle wavelengths of which can be freely positioned in the NIR region. However, it is preferable to carry out the measurement from both sides of point 104 sensitive to absorption (points 114 and 116). When measurements are performed from both sides of the point where the component is sensitive to absorption, an estimate 112 of the radiation strength level outside the absorption peak can be formed. The estimate is formed by interpolating the radiation strength at measuring points 108 and 110. There may be more than two measuring points outside the wavelength region 106 sensitive to absorption. Thus, the estimate 112 is insensitive to the absorption of the component, and it takes into account a possible change of the baseline in different measurements (the baseline corresponds to the line segment combining points 114, 112 and 116 in Figure 1A). Also an estimate 128 is insensitive to the absorption of the component and takes into account a possible change of the baseline (this baseline corresponding to the line segment which combines points 124, 126 and 128). When the radiation strength at point 106 sensitive to the kaolin absorption is compared with at least one radiation strength measured at a point that is not sensitive to absorption, the absorption strength of kaolin can be determined, for instance, as the difference of the radiation strengths at points 104 and 114 (or at points 104 and 116). Instead of the difference, the quotient or other similar mathematical operation can be employed. The most accurate measurement concerning the absorption strength at the wavelength band 106 is obtained when the difference is formed between the absorption peak 104 and the estimate 112.

[0014] Correspondingly, also the strength of the absorption caused by water at a wavelength band 118 having a middle wavelength of about 1940 nm can be measured by means of NIR radiation. In this case, the radiation strength 100 of the wavelength band 118 is compared with the radiation strength 124, 126 of the water absorption, which is measured at the insensitive wavelength band 120, 122. By measuring the amount of water, i.e. the moisture content, the measurement of the amount of other components can be specified.

[0015] Figure 1B shows absorption curves of paper in the MIR region. In the MIR region, the absorption strength of calcium carbonate can be measured similarly as the absorption strength of kaolin and water was measured in Figure 1A. The radiation strength 156 of calcium carbonate is measured by means of MIR radiation at a wavelength band 150 with a middle wavelength of about 3950 nm. In this measurement, too, the radiation strength is also measured outside the wavelength band 150 sensitive to the calcium carbonate absorption, at points 158 and/or 160, for instance. Furthermore, it is preferable to form the mean value 162 for the radiation strengths formed at the wavelength bands 152 and 154 and compare the radiation strength 156 with the mean value 162 in order to measure the absorption strength. The absorption strength of kaolin at a wavelength band 164 with a middle wavelength of about 2700 nm can also be measured by means of MIR radiation.

[0016] Let us now take a closer look on the method according to the invention, wherein the measurement is carried out by one detector. The measurement employs both MIR and NIR radiation, which are measured at different times. An MCT (Mercury Cadmium Telluride) detector or the like is used as a detector. The type of the detector is, however, not essential for the invention, but the essential matter is that the detector is capable of detecting the radiation to be measured. At least one component is measured from a paper or board coating by means of MIR radiation, and at least one component is measured from the coating by means of NIR radiation. To carry out the measurement in the method, IR radiation from the optical power source, chopped by means of a chopper into light pulses, is directed at the coating. In order to perform the detection, radiation emerging from the coating is bandpass filtered and also chopped synchronously with the IR radiation illuminating the coating. The IR radiation emerging from the coating comprises pulsed optical radiation from the optical power source and optical radiation emitted by the coating itself. Detection is performed in the measurement direction, which is other than the direction of specular reflection.

[0017] Let us now examine measurement carried out by using MIR radiation. At least one wavelength band of at least one component, the band being sensitive to the absorption of said at least one component in the MIR region, is bandpass filtered from the chopped optical radiation, and the strength of the MIR radiation sensitive to absorption is measured. The point of MIR radiation sensitive to absorption is the maximum absorption point of this component. In case of calcium carbonate, the absorption occurs at an optical band with a middle wavelength of about 3950 nm. In case of kaolin, the middle wavelength of absorption is about 2700 nm. An interference filter is used as a bandpass filter. Next, at least one absorption strength in proximity of the maximum absorption is measured in order to find out how strong the maximum absorption is compared to its environment. This is done in the following manner. A wavelength band of said at least one component, the band being insensitive to the absorption of said component in the MIR region, is bandpass filtered from the chopped IR radiation, and the strength of the MIR radiation insensitive to absorption is measured. Thereafter, the absorption strength of one or more components is determined by comparing, for each component specifically, the strength of the MIR radiation sensitive to absorption and the strength of the MIR radiation insensitive to absorption with each other. Finally, the amount of at least one component of the coating is determined in the MIR measurement on the basis of the strength of the MIR absorption.

[0018] Let us now examine more closely the measurement in the NIR region, which is similar to the measurement in the MIR region. A wavelength band of at least one other component, the band being sensitive to the absorption of said at least one other component in the NIR region, is bandpass filtered from the chopped IR radiation, and the strength of the NIR radiation sensitive to absorption is measured. The other material can be, for instance, kaolin, water, talc, gypsum, latex, starch, silicon or a special coating, such as temperature-sensitive ink. To measure the absorption strength, absorption is also measured at a reference wavelength, which is other than the wavelength band causing the maximum absorption. In this case, a wavelength band of said at least one other component, the band being insensitive to the absorption of said at least one other component in the NIR region, is bandpass filtered from the chopped IR radiation, and the strength of the NIR radiation insensitive to absorption is measured. Thereafter, the absorption strength of said one or more other components is measured by comparing, for each component specifically, the strength of the NIR radiation sensitive to absorption and the strength of the NIR radiation insensitive to absorption with each other. Finally, the amount of said at least one other component of the coating is determined on the basis of the strength of the NIR absorption.

[0019] When two detectors are used, the one of which measures MIR radiation and the other one NIR radiation, the measurement is otherwise similar, but both the MIR and the NIR measurement are performed simultaneously. NIR radiation can be detected with an InGaAs (Indium Gallium Arsenide) detector, for example. The type of the detector is, however, not essential for the invention; the most important thing is that the detector is capable of detecting the radiation to be measured.

[0020] Let us now examine the solution of the invention by means of Figure 2A which is a simplified block diagram of an inventive measuring apparatus. In the inventive solution, an optical radiation source 200 operating in at least the IR region transmits optical radiation through a chopper 202 to an object to be measured 205. The object of measurement 205 is of paper or board, the coating 204 of which will be measured. If uncoated paper or board is measured, the inventive solution does not naturally detect a sufficient amount of coating component for the measurement. However, paper may contain, for example, calcium carbonate as a filler, which can be observed in the measurement. When measuring coatings, the inventive solution measures the amount of the coating component. The chopper 202 allows optical radiation to momentarily pass through it, and part of the time the chopper 202 prevents optical radiation from penetrating it. What is essential in the operation of the chopper 202 is that during the illumination time, the object of measurement 205 is illuminated by IR radiation emitted by the optical power source 200 and during the off-period of illumination the object of measurement is not illuminated by IR radiation emitted by the optical power source 200.

This way, the chopper 202 chops the optical radiation into light pulses which hit an object to be measured 204. From the object of measurement 204, the optical radiation is reflected and scattered into different directions. Part of the optical radiation is directed towards block 206 where the optical radiation is bandpass filtered for the detection. At the same time, the optical radiation is also chopped. In the inventive solution, however, the optical radiation reflected from the object of measurement 204 is not measured from the direction of specular reflection. In block 206, filtering is performed separately with MIR and NIR filters, which are preferably interference filters. When the strength of MIR radiation is measured, the radiation from the object of measurement 204 is filtered with the MIR filter. When the strength of NIR radiation is measured, the radiation from the object of measurement 204 is filtered with the NIR filter. The detection time is the time when MIR or NIR radiation is allowed to pass to a detector 208 for measurement. The detection is performed synchronously at the same time as the object of measurement is illuminated with optical radiation. In addition, when the object of measurement 204 is not illuminated with IR radiation during the off-period of detection, radiation emerging from the coating is mainly prevented from passing to the detector 208 for the measurement. When a paper web which is the object of measurement is not illuminated by IR radiation, radiation emitted from the paper web is measured in order to detect and eliminate interferences affecting the measurement. The inventive solution also utilizes measurement of paper web temperature, carried out by means of IR radiation emerging from the paper web itself, when the paper web to be measured is not illuminated. In the temperature detection, the same detector as in the coating measurement is used. The timing of the illumination and detection is explained in greater detail in connection with Figure 5. During the coating measurement, the detector thus detects the filtered IR radiation and in the temperature measurement, it detects the filtered or not filtered radiation and converts the strength of the detected filtered IR radiation into an electrical signal of equal strength. This electrical signal is amplified in a preamplifier 209 and converted into digital in an A/D converter 211. On the basis of the digital signal, a digital signal processing block 220 measures the strength of the detected IR radiation, calculates the amount of coating and determines the temperature of the paper web. When the temperature is determined, the principle of black-body radiation known per se is applied, which means that the power of the radiation entering the detector is in relation to the temperature.

[0021] In coating and temperature measurements according to the inventive solution, MIR and NIR measurements can be performed at different time instants by means of one detector 208, from which a measurement signal converted into electrical form propagates to the preamplifier 209, A/D converter 211 and finally to digital signal processing in block 220.

[0022] Let us now examine the solution of the invention by means of Figure 2B. The solution is in many respects similar to the solution of Figure 2A, but now two detectors 208 and 210 are used. Optical radiation passing to the detector 208 is filtered in block 206 in such a way that only NIR radiation is allowed to pass to the detector 208 while only MIR radiation is allowed to pass to the detector 210. The measurement signal of both detectors is amplified in preamplifiers 212 and 216, and the electrical measurement signals are converted into digital in A/D converters 214 and 218. The digital signals are processed in the same way as in the signal processing block 220 in connection with Figure 2A.

[0023] Let us now observe by means of Figures 3A and 3B how the apparatus of the inventive solution is implemented. An optical power source 300 radiates optical power to a lens 302. The lens 302 makes an image of the optical power source 300 to a chopper 304. Instead of the lens 302, a lens combination or a concave mirror can be used, which makes an image of the optical power source 300 to the chopper 304. After the chopper 304, an image of the lens 302 making an image of the optical power source 300 to the chopper is made by a lens 306 to an object of measurement 311, which is of paper or board and comprises a coating 310. In this case, too, a lens combination or a concave mirror can be used instead of the lens 306. This illumination solution is called Köhler illumination and it provides the object of measurement 310 with even diffuse illumination. The illumination manner as such is not essential for the inventive solution, but it is sufficient that the surface to be measured is illuminated by IR radiation. A protective means 308, which is made of plastic, glass or some other material that passes through IR radiation to be measured, can be used between the lens 306 and the object of measurement 310. Particularly under industrial conditions, the protective means 308 protects imaging optics (lenses 302 and 306), the chopper 304 and the optical power source 300 from impurities.

[0024] Optical radiation which is reflected and scattered from the object of measurement 310 is collected by a lens 312 and focused on an optical fiber or fiber bundle 314. Between the object of measurement 310 and the lens 312 there is preferably a protective means 308, which, particularly under industrial conditions, also protects the receiver of optical radiation from impurities. From the fiber or fiber bundle 314 the optical radiation is transferred towards the filtering. The fiber or fiber bundle 314 is not necessarily required, since the optical radiation can be directly focused through the filter on the detector. By using the optical fiber or fiber bundle it is possible to position the object to be detected far from the object of measurement, in proximity of which impurities and high temperature could cause problems. In Figure 3A, which corresponds to the solution of Figure 2A, only one detector 322 is used in the measurement. One detector 322 can detect only MIR radiation or NIR radiation at a time, but not MIR radiation and NIR radiation simultaneously. Therefore, the optical radiation from the fiber 314 is filtered with a MIR filter 316 and a NIR filter 318 at different times. The filtered IR radiation is focused by a lens 320 on the detector 322. Lenses can be, for example, binary lenses, diffractive lenses or refractive lenses. The chopper 304 is preferably a rotary disc provided with teeth and a filter and illustrated in Figure 4 in greater detail. The rotary disc is rotated by a motor 324.

[0025] In Figure 3B, the transmitting part of optical radiation is similar to that of Figure 3A, but the receiving part which receives the optical radiation from the object of measurement 310 is slightly different. Between the object of measurement 310 and the lens 312 there is preferably a protective means 308, which, particularly under industrial conditions, protects also the receiver from impurities. The lens 312 focuses the radiation emerging from the object of measurement 310 on the optical fiber bundle 314. Since two detectors 334 and 336 can be used in this inventive solution, the optical fiber bundle 314 divides into two branches 314A and 314B. The optical radiation from the branch 314A is filtered by the MIR filter 316 and the radiation from the branch 314B is simultaneously filtered by the NIR filter 318. The filtered MIR radiation is focused by a lens 330 on the detector 334, and the filtered NIR radiation is focused by a lens 332 on the detector 336. Also in this case, the chopper 304 is preferably a rotary disc, which is described in greater detail in Figure 4. The disc is rotated by the motor 324. Instead of a rotary disc, optical switches known per se, such as mechanical, electro-optical, magneto-optical and acousto-optical switches, can be used for chopping optical radiation. The operation of the switches is timed as presented in Figures 5A to 5F.

[0026] Let us now take a closer look on the chopper used in the inventive solution by means of Figure 4. A chopper 400 is preferably a disc-like optical radiation chopper comprising teeth 402 for preventing IR radiation from passing from the optical power source to the surface to be measured, and teeth gaps 404 for allowing IR radiation to pass from the optical power source to the surface to be measured. The disc-like chopper 400 also comprises at least two MIR filters 406, 412 operating as bandpass filters correspondingly allowing MIR radiation to pass to the detector at least at two separate bands. The MIR filters 406, 412 are positioned circumferentially in the disc-like chopper 400. The maximum absorption point is measured at one bandpass MIR filter and a point outside the maximum absorption point is measured at the remaining one or more bands. Likewise, the chopper 400 comprises at least two NIR filters 408, 414 operating as bandpass filters and passing NIR radiation to the detector at two separate bands. The NIR filters 408, 414 are positioned circumferentially in the disc-like chopper 400. In this case, too, the optical band of one filter passes NIR radiation to the detector at the maximum absorption point of the measured coating component. One or more other NIR filters pass NIR radiation to the detector at bands other than that of the maximum absorption point. In addition, the disc-like chopper 400 comprises filter gaps 410 preventing IR radiation from propagating to the detectors. The filters 406, 408 are positioned such that when optical radiation 430 passes through the teeth 402 gaps 404 at the outer edge of the chopper 400 towards the object of measurement, the filters 406 and 408 simultaneously pass IR radiation 432 and 434 reflected and filtered from the paper web to the detectors. The chopper disc 400 is preferably rotated by an electric motor, and when the disc rotates, the teeth and filter gaps chop the radiation passing to the detector(s) and the surface to be measured. When only one detector is used, as in Figures 2A and 3A, MIR and NIR filters are positioned one after the other on the circumference of the disc-like chopper 400, and they filter MIR and NIR radiation alternately to one detector for the measurement (this is not shown in the figure, as it is obvious to a person skilled in the art). In the inventive solution, the middle wavelength of the bandpass of the MIR and NIR filters can be adjusted by changing the angle of inclination of the filters with respect to the direction of IR radiation penetrating the filters. An advantage of such a measuring arrangement is that increasing the number of MIR and NIR bands to be measured does not make the apparatus much more complicated, and optical power which is used in the measurement is not required more.

[0027] To measure the temperature of the paper web, IR radiation radiated by the paper web is passed through the filter to the detector at time instant 440. The measuring can also be performed such that one or more filters are replaced by an opening 442 in the chopper 400, which allows radiation to pass to the detector when no IR radiation is directed at the paper web. Thus, the detector can receive IR radiation from the paper web at its entire response band. It is advantageous to use a detector detecting MIR radiation for the temperature measurement. It is also possible to measure the temperature when one teeth 404 gap is covered and no IR radiation can pass from the optical radiation source to the paper web.

[0028] Let us now examine illumination and detection of an object of measurement by means of Figures 5A to 5F. The y-axis represents penetration on a free scale, the x-axis represents time T, and all curves are on the same time axis. In Figure 5A a curve 500 illustrates the penetration of a chopper between an optical power source and an object of measurement as a function of time. A curve 503 of Figure 5B illustrates the penetration of a chopper between an object of measurement and a detector as a function of time at a first wavelength to be measured. The chopper comprises optical filters and possibly also openings for passing optical radiation to the surface to be measured and for detection. In the beginning of the process, the chopper passes optical radiation to the surface to be measured and the detector (curve 530 in Figure 5C and 501 in Figure 5A). The curve 530 refers to measurement at a second wavelength to be measured. The measurement at different wavelengths is performed in the same manner.

[0029] Since in Figures 5A to 5F the surface measurement has already been performed at the second wavelength to be measured, the surface measurement at the first wavelength is described in greater detail by means of Figures 5A and 5B. First, the chopper prevents the first radiation used in the measurement from passing to the surface to be measured and the detector (curve points 502 and 508). In the inventive solution, the chopper between the object of measurement and the detector preferably starts passing IR radiation to the detector at the first wavelength to be measured (penetration at point 510) a little before the chopper between the optical power source and the object of measurement starts passing optical radiation to the surface to be measured (penetration at point 504). Interference level is then measured at time instant 514 for the first time. When also the chopper between the optical power source and the object of measurement starts passing optical radiation to the object of measurement (curve point 504), the total IR radiation strength of the object's first wavelength to be measured can be measured at time instant 516. In the inventive solution, the interference level is measured at the first wavelength to be measured for the second time when the chopper between the optical power source and the object of measurement prevents optical radiation from passing to the object of measurement at time instant 518. The chopper no longer passes the first radiation to be measured to the detector at curve point 512.

[0030] The measurement at a third wavelength can be started when the chopper starts passing radiation to the detector in accordance with the curve 532 of Figure 5D. Before that, however, the interference level can be measured when the chopper prevents the first radiation used in the measurement from passing to the surface to be measured and the detector at point 506. The interference level can be measured again, or the measurement can be utilized at point 518. Finally at point 534, the chopper also passes radiation to the surface to be measured (measuring point is not shown in Figure 5D). In this way, several components of the coating can be preferably measured at many wavelengths.

[0031] Figure 5E illustrates interference level measurement in greater detail. The measurement is similar to that of Figure 5A, but, due to interferences, the baseline of the measured radiation strength is slanting. In the inventive solution the first interference level D1 is measured at time instant 514. Thus, interferences from the detector, protective means (shown by a reference number 308 in Figures 3A and 3B), object of measurement and electronical and optical operation of the apparatus in general can be measured. For instance, the temperature of the paper web to be coated is usually fairly high (about 100°C, for instance) and therefore the paper web radiates quite much in the MIR and NIR regions. When also the chopper between the optical power source and the object of measurement starts passing optical radiation to the object of measurement (curve point 504), the actual MD measurement of the total IR radiation strength of the object can be performed at time instant 516. In the inventive solution, yet another measurement of the interference level D2 is performed when the chopper between the optical power source and the object of measurement prevents optical radiation from passing to the object of measurement at time instant 518. The average interference level D is formed by adding the interference levels D1 and D2 together and dividing this by two, i.e. by utilizing the formula $D = (D1 + D2)/2$. This provides the advantage that an average interference level D can be determined at the measuring instant 516 also when the interference level drifts. In the digital signal processing section, the measurement signal strength M free of interference is formed by the difference of the actual measurement signal MD and the interference level D, i.e. according to the formula $M = MD - D$. Other mathematical operations can be used in calculating interferences, too.

[0032] Figure 5F illustrates the timing of the temperature measurement of a paper web according to the invention. The measurement is carried out when the paper web is not illuminated by pulsed optical radiation at instants 540 and 542. The measurement times can thus be anywhere between the light pulses. Radiation emerging from the paper web is passed to the detector at time intervals 544 and 546. The measurement can also be carried out when the source emitting optical radiation to the paper web is switched off. Hence, the temperature of the paper web can be measured each time when IR radiation radiating from the paper web is passed to the detector. By using the measured temperature, the temperature of the paper web can be adjusted and the drying process of the paper web and of the coated paper in particular can be optimized. In IR drying, IR radiation is directed from an IR radiation source at the paper web, the IR radiation increasing the temperature of the paper web. For example radiators heated by electricity or gas, i.e. IR dryers, can function as IR radiation sources.

[0033] The temperature of the paper web is preferably measured at several points in the transverse direction of the paper web in order to form a temperature profile of the paper web. The profile can be measured by means of one or more sensors such that the sensors are static or that the sensors traverse, i.e. move back and forth in the transverse direction of the paper web. The measuring arrangement thus comprises a desired number of sensors measuring the paper web which are functionally connected to a measurement and control block. The measurement block preferably controls dryers. Dryers include blow dryers, steam-pressure cylinder dryers and IR dryers. The solution of the invention can control, optimize and monitor the condition of the dryers. In the coating process, the temperature of the coating paste can be prevented from increasing so high that the surface will solidify. If the surface temperature of the coating paste increases too much and the surface solidifies, the water inside the paste boils and explodes the surface. In addition, the temperature of the paper web can be measured at several locations in the machine direction of the web in order to form a temperature profile of the paper web in the machine direction. By optimizing the drying process, energy can be saved. The measuring arrangement of the paper web temperature keeps the temperature of the paper web constant both in the transverse direction and in the machine direction. As a result, paper shrinkage remains constant, which reduces folding and enables a high production rate.

[0034] When the temperature of the paper web is measured before and after the dryer, the measured temperature can be used for monitoring the condition of the dryer and for informing the operator of the paper machine of a potential defect.

[0035] Figure 6 illustrates a paper coating process of a paper machine. When paper or board is coated several times, the amount of coating of each coating layer can be measured by the inventive solution. As a paper web 600 travels towards the coating process, the amount of materials sensitive to measurement are measured from uncoated paper. Fillers, the most common of which are kaolin, talc and calcium carbonate, are added to paper pulp, for example. Paper is first coated on both sides in coating heads 604 and 606. The amount of a coating component or coating components is measured by measuring apparatuses 608 and 612 according to the inventive method. The measurement result is transferred from the measuring apparatus 608 to a controller 610 which controls the coating head 606 and aims at keeping the amount of coating at a desired level. The amount of coating can be increased or decreased depending on whether the measured amount of coating is big or small with respect to the desired level. The controller 610 is preferably connected to a computer (not shown in the figure) controlling the entire paper machine. Similarly, a coating head 616 applies coating on paper from above, and the total amount of coating is measured by a measuring apparatus 618. The measurement result is transferred to a controller 620 controlling the coating head 616. As the controller 620 can utilize the result of the previous coating measurement (has a direct connection to the measuring apparatus of the previous coating, the controller or to the computer of the paper machine), the amount of the component of the last coating layer can be calculated as a difference of the latest and the previous measurement in a manner that is obvious to a person skilled in the art. The same steps are also performed in the measurement which is to be performed from under the paper web. In that case, a measuring apparatus 622 measures the total amount of coating and transfers the measurement result to a controller 624. The controller 624 calculates the amount of the component of the last coating layer and controls a coating head 626. By means of a measuring apparatus 628, the amount of coating formed by a coating head 632 can also be measured, and, if necessary, the amount of coating can be adjusted by means of a controller 630. The process can be continued in this way, and the amount of components of more and more coating layers can be measured. The amount of component is measured as a surface density, the SI unit of which is g/m^2.

[0036] Let us now examine calibration measurement which improves the operation of the apparatus. In the calibration measurement, M measurements are carried out in the MIR and NIR region at a desired wavelength band. The measurement at the i:th wavelength band, where i is i = 1,..., N, is carried out as follows. A measurement signal U_i^{pap} which is proportional to the intensity of the i:th wavelength band of the paper or board coating is measured. A measurement signal U_i^{ref} which is proportional to the intensity of the reference object with known properties is measured at a corresponding wavelength band. Then, paper or board 205, 311 to be measured is used instead of the reference object in Figures 2A, 2B, 3A. The absorbancy A_i of the i:th wavelength band is formed in the following manner: $A_i = -\log\left(\frac{U_i^{pap}}{U_i^{ref}}\right)$. Since there are at least two components, the amount of j:th component $\hat{C}^j$ is formed as follows: $\hat{C}^j = b_{offset}^j + \sum_{i=1}^{N} b_i^j A_i$, where j is the index of each component. Weighting coefficients b_{offset}^j and b_i^j can be determined separately by determination measurements which use paper and board samples with known optical properties, containing each component. Since the properties of these objects of measurement are known, correct values for the amount $\hat{C}^j$ and the absorbancy A_i are known in advance in the determination measurements. By performing a number of measurements for each component by means of known objects of measurement, the weighting coefficients b_{offset}^j and b_i^j can be adjusted such that the results of the determination measurements and the results known in advance are statistically congruent. The coating measurement result is often not linear with respect to the amount of coating. The measurement results can thus be linearized by a polynomial of degree two for example in the following manner: $C_w^j = a_1 \hat{C}^{j\,2} + a_2 \hat{C}^j + a_3$. Coefficients a_1, a_2 and a_3 are selected such that the measurement response becomes linear. The total amount of coating C_{wu}^j for for one component is calculated by means of formula calculation for example in the following manner:

$$C_{wu}^{j} = \frac{C_{w}^{j}}{AC_{j}} \cdot 100\%,$$

where AC represents the component content (%) in the coating paste. When the coating contains several components, the total amount of coating C_{wu} is calculated as follows:

$$C_{wu} = \frac{\sum_{j=1}^{N} C_{w}^{j}}{\sum_{j=1}^{N} AC_{j}} \cdot N \cdot 100\%,$$

where N represents the amount of components in the coating. In addition, to specify the measurement, offset and slope corrections obvious to a person skilled in the art can be performed.

[0037] When the weighting coefficients are determined, the calibration measurement can be performed with the objects of measurement, whereafter the measuring apparatus operates reliably without another calibration measurement. A checking measurement, wherein U_{i}^{ref} is measured, is carried out at intervals under measuring conditions and, in order to eliminate the effect of changes occurred in the measuring apparatus, in the measurement result of the actual components.

[0038] Although the invention has been described above with reference to the example according to the attached drawings, it is obvious that the invention is not restricted thereto, but it can be modified in a variety of ways within the scope of the inventive idea disclosed in the attached claims.

Claims

1. A method for measuring a paper or board coating by means of IR radiation, the coating (204, 310) comprising at least two components, the method comprising:

by one detector (208, 322) or simultaneously by two respective detectors (208, 210) measuring at least one component from the coating (204, 310) by using MIR radiation in the spectrum band of 2500 nm to 20000 nm and at least one other component by using NIR radiation in the spectrum band of 700 nm to 2500 nm, and, in order to measure the at least one component by using MIR radiation:

directing IR radiation at the coating (204, 310);
chopping, by a chopper (202, 304, 400), the IR radiation directed at the coating (204, 310);
chopping, by the chopper (202, 304, 400), the IR radiation emerging from the coating (204, 310) synchronously with the IR radiation illuminating the coating;
bandpass filtering, by a filter (316, 406) of the chopper (202, 304, 400), a MIR wavelength band which is sensitive to the absorption of said at least one component from the IR radiation emerging from the coating (204, 310),
measuring the strength of the MIR radiation sensitive to the absorption;
bandpass filtering, by a filter (412) of the chopper (202, 304, 400), a MIR wavelength band which is insensitive to the absorption of said at least one component from the IR radiation emerging from the coating (204, 310),
measuring the strength of the MIR radiation insensitive to the absorption;
measuring the strength of the MIR absorption of the at least one component by comparing the strength of the MIR radiation sensitive to the absorption and the strength of the MIR radiation insensitive to the absorption with each other;
determining the amount of the at least one component of the coating (204, 310) on the basis of the measured strength of the MIR absorption; and,
in order to measure the at least one other component by using NIR radiation:

bandpass filtering, by a filter (318, 408) of the chopper (202, 304, 400), a NIR wavelength band which is sensitive to the absorption of the at least one other component from the IR radiation emerging from the coating (204, 310),
measuring the strength of the NIR radiation sensitive to the absorption;
bandpass filtering, by a filter (414) of the chopper (202, 304, 400), a NIR wavelength band which is insensitive to the absorption of the at least one other component from the IR radiation emerging from the coating (204, 310),
measuring the strength of the NIR radiation insensitive to the absorption;
measuring the strength of the NIR absorption of the at least one other component by comparing the strength of the NIR radiation sensitive to the absorption and the strength of the NIR radia-

tion insensitive to the absorption with each other; and
determining the amount of the at least one other component of the coating (204, 310) on the basis of the measured strength of the NIR absorption.

2. A method as claimed in claim 1, **characterized by** measuring MIR and NIR radiation by means of separate detectors.

3. A method as claimed in claim 1,**characterized by** performing the measurement in the method from the radiation reflected from the coating (204, 310) in the measurement direction, which is other than the direction of specular reflection.

4. A method as claimed in claim 1, **characterized by** chopping the IR radiation illuminating the coating (204, 310) and the IR radiation emerging from the coating with a disc-like chopper (304, 400) comprising teeth (402) for preventing IR radiation from passing, and teeth gaps (404) for allowing IR radiation to pass.

5. A method as claimed in claim 1, **characterized by** chopping and bandpass filtering the IR radiation emerging from the coating (204, 310) with a disc-like chopper (304, 400) comprising MIR and NIR filters (406, 408) for allowing IR radiation to pass, and filter (406, 408) gaps (410) for preventing IR radiation from passing.

6. A method as claimed in claim 1, **characterized by**, in order to calibrate the operation of the method in both the MIR and NIR region, measuring a measurement signal U_i^{pap} which is proportional to the intensity of the i:th wavelength band of the paper or board coating (204, 310);

measuring a measurement signal U_i^{ref} which is proportional to the intensity of the reference object with known properties at a corresponding wavelength band;
forming the absorbancy A_i of the i:th wavelength band in the following manner:

$$A_i = -\log\left(\frac{U_i^{pap}}{U_i^{ref}}\right);$$

and
forming the amount of j:th component $\hat{C}^j$ as follows:

$$\hat{C}^j = b_{offset}^j + \sum_{i=1}^{N} b_i^j A_i ,$$

where j is the index of each component, i is the index of the wavelength band used in the measurement and measurements are performed at N wavelength bands such that i runs from 1 to N.

7. A method as claimed in claim 1, **characterized by** adjusting the middle wavelength of the bandpass of the MIR and NIR filters (406, 408) by the angle of inclination of the filters (406, 408) with respect to the direction of IR radiation penetrating the filters.

8. A method as claimed in claim 1, **characterized in that**, when paper or board is coated several times, the measurement of the method is performed before and/or after the coating to measure the coating layer.

9. A method as claimed in claim 1, **characterized by** measuring one or more coating (204, 310) components, such as calcium carbonate, kaolin, silicon and water, by using MIR radiation, and measuring one or more components, such as kaolin, talc, gypsum, latex, starch, silicon and water, by using NIR radiation, and, when water is measured, determining the moisture content.

10. A method as claimed in claim 9, **characterized in that**, when calcium carbonate and kaolin are measured by means of MIR radiation, the absorption of calcium carbonate is measured at a wavelength band with a middle wavelength of about 3950 nm, and the absorption of kaolin is measured by means of MIR radiation at a wavelength band with a middle wavelength of about 2700 nm.

11. A method as claimed in claim 9, **characterized in that**, when kaolin and water are measured by means of NIR radiation, the absorption of kaolin is measured at a wavelength band with a middle wavelength of about 2208 nm, and the absorption of water is measured by means of NIR radiation at a wavelength band with a middle wavelength of about 1940 nm.

12. A method as claimed in claim 1, **characterized in that** in the measurements performed by means of both MIR and NIR radiation, at least one wavelength band (108, 110, 120, 122) insensitive to the absorption of the component is measured on both sides of the absorbing wavelength band (106, 118) and on the basis of the measured results, the strength of the radiation insensitive to absorption is formed, and, in order to determine the absorption strength, the strength of the radiation sensitive to absorption and the formed strength of the radiation insensitive to absorption are compared with each other.

13. A method as claimed in claim 1, **characterized by**, in the measurement performed by means of both MIR and NIR radiation to measure the absorption by

means of the radiation strength,

chopping the IR radiation directed at the coating such that during the illumination time (504), the coating (204, 310) is illuminated by IR radiation and during the off-period of illumination (502, 506), the coating (204, 310) is not illuminated by IR radiation;
bandpass filtering the IR radiation emerging from the coating such that during detection time (510), the radiation from the coating is allowed to pass to the measurement, the detection time being longer than the illumination time (504), and during the off-period of the detection (508, 512), the radiation from the coating is prevented from passing to the measurement;
when radiation emerging from the coating is passed to the measurement during the detection time (510) before the illumination time (504) begins, measuring a first interference level of the coating;
when radiation emerging from the coating is passed to the measurement during the detection time (510) and the coating is illuminated during the illumination time (504) simultaneously, measuring the strength of the total radiation comprising both the interference and the radiation to be measured;
when radiation emerging from the coating is passed to the measurement during the detection time (510) after the illumination time (504) has ended, measuring a second interference level of the coating;
forming the interference level from the mean value of the first and second interference; and
subtracting the averaged interference level from the strength of the total radiation.

14. A method as claimed in claim 1, **characterized by** directing IR radiation at the coating (204, 310) such that an image of the surface emitting IR radiation is made to the chopping chopper (304, 400) and an image of an imaging lens (302) is made to the coating (204, 310).

15. A method as claimed in claim 1, **characterized by** measuring also the IR radiation of paper or board during the off-period of illumination (502) when the coating (204, 310) is not illuminated with IR radiation, and determining the temperature of paper or board from the measured IR radiation.

16. An apparatus for measuring a paper or board coating by means of IR radiation, the coating (204, 310) comprising at least two components, the apparatus comprising one detector (208, 322) for measuring at least one component from the coating (204, 310) by using MIR radiation in the spectrum band of 2500 nm to 20000 nm and at least one other component by using NIR radiation in the spectrum band of 700 nm to 2500 nm, or
first and second detectors (208, 210) arranged to simultaneously measure at least one component from the coating (204, 310) by using MIR radiation in the spectrum band of 2500 nm to 20000 nm and at least one other component by using NIR radiation in the spectrum band of 700 nm to 2500 nm,
the apparatus comprising:

an optical power source (200, 300) for radiating IR radiation to the coating;
a chopper (202, 304, 400) for chopping the IR radiation directed at the coating (204, 310) and for chopping the IR radiation emerging from the coating synchronously with the IR radiation illuminating the coating; and,
in order to perform MIR measurement for the at least one component the apparatus comprises:

a bandpass filter (316, 406) in the chopper (202, 304, 400) for filtering a MIR wavelength band which is sensitive to the absorption of the at least one component from the IR radiation emerging from the coating;
the one detector (208, 322) or the first detector (208) arranged to detect MIR radiation sensitive to absorption and to convert the strength of the detected MIR radiation into an electrical signal of equal strength, by means of which signal the apparatus is arranged to measure the strength of the MIR radiation sensitive to absorption;
a bandpass filter (316, 412) in the chopper (202, 304, 400) for filtering a MIR wavelength band which is insensitive to the absorption of the at least one component from the IR radiation emerging from the coating;
the one detector (208, 322) or the first detector (208) arranged to detect MIR radiation insensitive to absorption and to convert the strength of the detected MIR radiation into an electrical signal of equal strength, by means of which signal the apparatus is arranged to measure the strength of the MIR radiation insensitive to absorption;
the apparatus being arranged to measure the strength of the absorption of the at least one component by comparing the strength of the MIR radiation sensitive to absorption and the strength of the MIR radiation insensitive to absorption with each other;
the apparatus being arranged to determine the amount of the at least one component of the coating on the basis of the measured strength of at least one MIR absorption;
and, in order to perform NIR measurement

for the at least one other component the apparatus comprises:

a bandpass filter (318, 408) in the chopper (202, 304, 400) for filtering a wavelength band which is sensitive to the absorption of said at least one other component in the NIR region from the IR radiation emerging from the coating;
the one detector (208, 322) or the second detector (210) arranged to detect NIR radiation sensitive to absorption and to convert the strength of the detected NIR radiation into an electrical signal of equal strength, by means of which signal the apparatus is arranged to measure the strength of the NIR radiation sensitive to absorption;
a bandpass filter (318, 414) in the chopper (202, 304, 400) for filtering a wavelength band which is insensitive to the absorption of said at least one other component in the NIR region from the IR radiation emerging from the coating;
the one detector (208, 322) or the second detector (210) arranged to detect NIR radiation insensitive to absorption and convert the strength of the detected NIR radiation into an electrical signal of equal strength, by means of which signal the apparatus is arranged to measure the strength of the NIR radiation insensitive to absorption;
the apparatus being arranged to measure the strength of the absorption of the at least one other component by comparing the strength of the NIR radiation sensitive to absorption and the strength of the NIR radiation insensitive to absorption with each other;
the apparatus being arranged to determine the amount of the at least one other component of the coating on the basis of the measured strength of at least one NIR absorption.

17. An apparatus as claimed in claim 16, **characterized in that** the apparatus is arranged to measure the radiation reflected from the coating in the measurement direction, which is other than the direction of specular reflection.

18. An apparatus as claimed in claim 16, **characterized in that** the chopper (202, 304, 400) for chopping the IR radiation illuminating the coating and IR radiation emerging from the coating (204, 310) is a disc-like chopper comprising teeth (402) for preventing IR radiation from passing, and teeth gaps (404) for allowing IR radiation to pass.

19. An apparatus as claimed in claim 16, **characterized in that** the disc-like chopper (304, 400) comprises MIR and NIR filters (406, 408, 412, 414) as bandpass filters for allowing IR radiation to pass, and filter gaps (410) for preventing IR radiation from passing, whereby the disc-like chopper (304, 400) is arranged to chop and bandpass filter the IR radiation emerging from the coating (204, 310).

20. An apparatus as claimed in claim 16, **characterized in that** in order to calibrate the operation of the apparatus, the apparatus is arranged to measure in both the MIR and NIR region a measurement signal U_i^{pap} which is proportional to the intensity of the i:th wavelength band of the paper or board coating (204, 310);

to measure a measurement signal U_i^{ref} which is proportional to the intensity of the reference object with known properties at a corresponding wavelength band;
to form the absorbancy A_i of the i:th wavelength band in the following manner:

$$A_i = -\log\left(\frac{U_i^{pap}}{U_i^{ref}}\right);$$

and

to form the amount of j:th component $\hat{C}^j$ as follows:

$$\hat{C}^j = b_{offset}^j + \sum_{i=1}^{N} b_i^j A_i ,$$

where j is the index of each component, i is the index of the wavelength band used in the measurement, and measurements are performed at N wavelength bands such that i runs from 1 to N.

21. An apparatus as claimed in claim 16, **characterized in that** the middle wavelength of the bandpass of the MIR and NIR filters (406, 408, 412, 414) is adjustable by changing the angle of inclination of the filters with respect to the direction of IR radiation penetrating the filters.

22. An apparatus as claimed in claim 16, **characterized in that** the apparatus comprises several apparatus units (608, 612, 618, 622, 628) and when paper or board is coated several times, each apparatus unit is arranged to measure a coating layer before and/or after each coating operation.

23. An apparatus as claimed in claim 16, **characterized in that** the apparatus is arranged to measure one or more coating (204, 310) components, such as calcium carbonate, kaolin, silicon and water, by using MIR radiation, and the apparatus is arranged to measure one or more components, such as kaolin, talc, gypsum, latex, starch, silicon and water, by using NIR radiation, and, when water is measured, the apparatus is arranged to determine the moisture content.

24. An apparatus as claimed in claim 23, **characterized in that** when calcium carbonate and kaolin are measured, the apparatus is arranged to measure the absorption of calcium carbonate at a wavelength band with a middle wavelength of about 3950 nm by means of MIR radiation, and the apparatus is arranged to measure the absorption of kaolin at a wavelength band with a middle wavelength of about 2700 nm by means of MIR radiation.

25. An apparatus as claimed in claim 23, **characterized in that** when kaolin and water are measured, the apparatus is arranged to measure the absorption of kaolin at a wavelength band with a middle wavelength of about 2208 nm by means of NIR radiation, and the apparatus is arranged to measure the absorption of water at a wavelength band with a middle wavelength of about 1940 nm by means of NIR radiation.

26. An apparatus as claimed in claim 16, **characterized in that** in the measurements performed by means of both MIR and NIR radiation, the apparatus is arranged to measure at least one wavelength band insensitive to the absorption of the component on both sides of the absorbing wavelength band and to form, on the basis of the measured results, the strength of the radiation insensitive to absorption, and, in order to determine the absorption strength, to compare the strength of the radiation sensitive to absorption and the formed strength of the radiation insensitive to absorption with each other.

27. An apparatus as claimed in claim 16, **characterized in that** in the measurements performed by means of both MIR and NIR radiation to measure the absorption by means of the radiation strength, the apparatus is arranged

to chop the IR radiation directed at the coating such that during the illumination time (504), the coating is illuminated by IR radiation and during the off-period of illumination (502, 506), the coating is not illuminated by IR radiation;
to chop the IR radiation emerging from the coating such that during detection time (510), the radiation from the coating is allowed to pass to the measurement, the detection time being longer than the illumination time (504), and during the off-period of the detection (508, 512), the radiation from the coating is prevented from passing to the measurement;
when radiation emerging from the coating is passed to the measurement during the detection time (510) before the illumination time (504) begins, to measure a first interference level of the coating;
when radiation emerging from the coating is passed to the measurement during the detection time (510) and the coating is illuminated during the illumination time (504) simultaneously, to measure the strength of the total radiation comprising both the interference and the radiation to be measured;
when radiation emerging from the coating is passed to the measurement during the detection time (510) after the illumination time (504) has ended, to measure a second interference level of the coating;
to form the interference level from the mean value of the first and second interference; and
to subtract the averaged interference level from the strength of the total radiation.

28. An apparatus as claimed in claim 16, **characterized in that** the apparatus is arranged to make an image of IR radiation of the surface emitting IR radiation to the chopping chopper (202, 304, 400) and an image of an imaging lens (302) to the coating (204, 310).

29. An apparatus as claimed in claim 16, **characterized in that** the apparatus is also arranged to measure the IR radiation of paper or board during the off-period of illumination (502), when the coating (204, 310) is not illuminated with IR radiation, and the apparatus is arranged to determine the temperature of paper or board from the measured IR radiation.

Patentansprüche

1. Verfahren zum Messen einer Papier- oder Plattenbeschichtung mittels IR-Strahlung, wobei die Beschichtung (204, 310) mindestens zwei Komponenten aufweist, wobei das Verfahren aufweist:

durch einen Detektor (208, 322) oder gleichzeitig durch zwei entsprechende Detektoren (208, 210), Messen von zumindest einer Komponente von der Beschichtung (204, 310) durch Verwenden von MIR-Strahlung im Spektralband von 2500 nm bis 20000 nm und zumindest einer anderen Komponente durch Verwenden von NIR-Strahlung im Spektralband von 700 nm bis 2500 nm, wobei, um die zumindest eine Komponente unter Verwendung von MIR-Strahlung zu messen:

Richten von IR-Strahlung auf die Beschichtung (204, 310);
Choppen, durch einen Chopper (202, 304, 400), der auf die Beschichtung (204, 310) gerichteten IR-Strahlung;
Choppen, durch den Chopper (202, 304, 400), der IR-Strahlung, die aus der Beschichtung (204, 310) entsteht, synchron mit der die Beschichtung bestrahlenden IR-Strahlung;
Bandpassfiltern, durch einen Filter (316, 406) des Choppers (202, 304, 400), eines MIR-Wellenlängenbandes, das bezüglich der Absorption der zumindest einen Komponente von der von der Beschichtung (204, 310) abgegebenen IR-Strahlung empfindlich ist;
Messen der Stärke der MIR-Strahlung, die bezüglich der Absorption empfindlich ist;
Bandpassfiltern, durch einen Filter (412) des Choppers (202, 304, 400), eines MIR-Wellenlängenbandes, das bezüglich der Absorption der zumindest einen Komponente von der von der Beschichtung (204, 310) entstehenden IR- Strahlung unempfindlich ist;
Messen der Stärke der MIR-Strahlung, die bezüglich der Absorption unempfindlich ist;
Messen der Stärke der MIR-Absorption der zumindest einen Komponente durch miteinander Vergleichen der Stärke der MIR-Strahlung, die bezüglich der Absorption empfindlich ist, und der Stärke der MIR-Strahlung, die bezüglich der Absorption unempfindlich ist;
Bestimmen der Menge der zumindest einen Komponente der Beschichtung (204, 310) auf der Basis der gemessenen Stärke der MIR-Absorption; und
um die zumindest eine andere Komponente durch Verwenden von NIR-Strahlung zu messen:

Bandpassfiltern, durch einen Filter (318, 408) des Choppers (202, 304, 400), eines NIR-Wellenlängenbandes, das bezüglich der Absorption der zumindest einen anderen Komponente von der von der Beschichtung (204, 310) abgegebenen IR-Strahlung empfindlich ist;
Messen der Stärke der NIR-Strahlung, die bezüglich der Absorption empfindlich ist;
Bandpassfiltern, durch einen Filter (414) des Choppers (202, 304, 400), eines NIR-Wellenlängenbandes, das bezüglich der Absorption der zumindest einen anderen Komponente von der von der Beschichtung (204, 310) abgegebenen IR-Strahlung unempfindlich ist;
Messen der Stärke der NIR-Strahlung, die bezüglich der Absorption unempfindlich ist;
Messen der Stärke der NIR-Absorption der zumindest einen anderen Komponente durch miteinander Vergleichen der Stärke der NIR-Strahlung, die bezüglich der Absorption empfindlich ist, und der Stärke der NIR, Strahlung, die bezüglich der Absorption unempfindlich ist; und
Bestimmen der Menge der zumindest einen anderen Komponente der Beschichtung (204, 310) auf der Basis der gemessenen Stärke der NIR-Absorption.

2. Verfahren gemäß Anspruch 1, **gekennzeichnet durch** Messen von MIR- und NIR-Strahlung mittels separaten Detektoren.

3. Verfahren gemäß Anspruch 1, **gekennzeichnet durch** Durchführen der Messung, in dem Verfahren, von der Strahlung, die von der Beschichtung (204, 310) in der Messrichtung, die sich von der Richtung einer spiegelnden Reflexion unterscheidet, reflektiert wird.

4. Verfahren gemäß Anspruch 1, **gekennzeichnet durch** Choppen der die Beschichtung (204, 310) beleuchtenden IR-Strahlung und der aus der Beschichtung entstehenden IR-Strahlung mit einem plattenähnlichen Chopper (304, 400) mit Zähnen (402) zum Verhindern einer Durchstrahlung von IR-Strahlung, sowie Zahnlöchern (404) zum Ermöglichen einer Durchstrahlung von IR-Strahlung.

5. Verfahren gemäß Anspruch 1, **gekennzeichnet durch** Choppen und Bandpassfiltern der von der Beschichtung (204, 310) abgegebenen IR-Strahlung mit einem plattenähnlichen Chopper (304, 400) mit MIR- und NIR-Filtern (406, 408) zum Ermöglichen der Durchstrahlung von IR-Strahlung, sowie Filter-(406, 408) -Lücken (410) zum Verhindern der Durchstrahlung von IR-Strahlung.

6. Verfahren gemäß Anspruch 1, **gekennzeichnet durch,** um die Operation des Verfahrens in sowohl der MIR- als auch der NIR-Region zu kalibrieren, Messen eines Messsignals U_i^{pap}, die proportional zur Intensität des i-ten Wellenlängenbandes der Papier- oder Plattenbeschichtung (204, 310) verläuft;

Messen eines Messsignals U_i^{ref}, das proportio-

nal zur Intensität des Referenzobjekts mit bekannten Eigenschaften in einem entsprechenden Wellenlängenband verläuft;
Bilden der Absorptionsfähigkeit A_i des i-ten Wellenlängenbandes auf die folgende Weise:

$$A_i = -log\left(\frac{U_i^{pap}}{U_i^{ref}}\right);$$

und

Bilden der Größe der j-ten Komponente $\hat{C}^j$ wie folgt:

$$\hat{C}^j = b^j_{offset} + \sum_{i=1}^{N} b_i^j A_i$$

wobei j der Index der jeweiligen Komponente ist, i der Index des bei der Messung verwendeten Wellenlängenbandes ist und Messungen in N Wellenlängenbändern durchgeführt werden, sodass i von 1 bis N verläuft.

7. Verfahren gemäß Anspruch 1, **gekennzeichnet durch** Anpassen der mittleren Wellenlänge des Bandpasses der MIR- und NIR-Filter (406, 408) durch den Neigungswinkel der Filter (406, 408) bezüglich der Richtung der IR-Strahlung, die die Filter durchdringt.

8. Verfahren gemäß Anspruch 1, **dadurch gekennzeichnet, dass** wenn Papier oder eine Platte mehrere Male beschichtet wird, die Messung des Verfahrens vor und/oder nach der Beschichtung zum Messen der Beschichtungsschicht durchgeführt wird.

9. Verfahren gemäß Anspruch 1, **gekennzeichnet durch** Messen von einer oder mehreren Beschichtungs- (204, 310) -Komponenten, wie etwa Kalziumcarbonat, Kaolin, Silizium und Wasser, durch Verwenden von MIR-Strahlung, und Messen von einer oder mehreren Komponenten, wie etwa Kaolin, Talkum, Gips, Latex, Stärke, Silizium und Wasser, durch Verwenden von NIR-Strahlung, und, wenn Wasser gemessen wird, Bestimmen des Feuchtigkeitsgehaltes.

10. Verfahren gemäß Anspruch 9, **dadurch gekennzeichnet, dass** wenn Kalziumcarbonat und Kaolin mittels MIR-Strahlung gemessen werden, die Absorption von Kalziumcarbonat in einem Wellenlängenband mit einer mittleren Wellenlänge von ungefähr 3950 nm gemessen wird, und die Absorption von Kaolin mittels MIR-Strahlung in einem Wellenlängenband mit einer mittleren Wellenlänge von ungefähr 2700 nm gemessen wird.

11. Verfahren gemäß Anspruch 9, **dadurch gekennzeichnet, dass** wenn Kaolin und Wasser mittels NIR-Strahlung gemessen werden, die Absorption von Kaolin in einem Wellenlängenband mit einer mittleren Wellenlänge von ungefähr 2208 nm gemessen wird, und die Absorption von Wasser mittels NIR-Strahlung in einem Wellenlängenband mit einer mittleren Wellenlänge von ungefähr 1940 nm gemessen wird.

12. Verfahren gemäß Anspruch 1, **dadurch gekennzeichnet, dass** in den mittels sowohl MIR- als auch NIR-Strahlung durchgeführten Messungen zumindest ein Wellenlängenband (108, 110, 120, 122), das unempfindlich bezüglich der Absorption der Komponente ist, an beiden Seiten des Absorptionswellenlängenbandes (106, 118) gemessen wird und auf der Basis der gemessenen Ergebnisse die Stärke der Strahlung, die bezüglich der Absorption unempfindlich ist, gebildet wird, und, um die Absorptionsstärke zu bestimmen, die Stärke der Strahlung, die bezüglich der Absorption empfindlich ist, und die gebildete Stärke der Strahlung, die bezüglich der Absorption unempfindlich ist, miteinander verglichen werden.

13. Verfahren gemäß Anspruch 1, **gekennzeichnet durch,** in der mittels sowohl MIR- als auch NIR-Strahlung durchgeführten Messung zum Messen der Absorption mittels der Strahlungsstärke,

Choppen der auf die Beschichtung gerichteten IR-Strahlung, sodass während der Belichtungszeit (504) die Beschichtung (204, 310) durch IR-Strahlung belichtet wird, und während der AUS-Periode der Belichtung (502, 506), die Beschichtung (204, 310) nicht durch IR-Strahlung belichtet wird;
Bandpassfiltern der IR-Strahlung, die aus der Beschichtung entsteht, sodass es während der Erfassungszeit (510) der Strahlung von der Beschichtung möglich ist, die Messung zu durchlaufen, wobei die Erfassungszeit länger ist als die Belichtungszeit (504), und während der AUS-Periode der Erfassung (508, 512) die Strahlung von der Beschichtung gehindert wird, die Messung zu durchlaufen;
wenn von der Beschichtung entstehende Strahlung während der Erfassungszeit (510) die Messung durchläuft, bevor die Belichtungszeit (504) beginnt, Messen eines ersten Interferenzniveaus der Beschichtung;
wenn die von der Beschichtung entstehende Strahlung während der Erfassungszeit (510) die Messung durchläuft und die Beschichtung während der Belichtungszeit (504) gleichzeitig belichtet wird, Messen der Stärke der Gesamtstrahlung, die sowohl die Interferenz als auch

die zu messende Strahlung aufweist;
wenn die von der Beschichtung entstehende Strahlung während der Erfassungszeit (510) die Messung durchläuft, nachdem die Belichtungszeit (504) geendet ist, Messen eines zweiten Interferenzniveaus der Beschichtung;
Bilden des Interferenzniveaus aus dem Mittelwert der ersten und zweiten Interferenz; und
Subtrahieren des gemittelten Interferenzniveaus von der Stärke der Gesamtstrahlung.

14. Verfahren gemäß Anspruch 1, **gekennzeichnet durch** Richten von IR-Strahlung auf die Beschichtung (204, 310), sodass ein Bild der Oberfläche, die die IR-Strahlung abgibt, für den choppenden Chopper (304, 400) erstellt wird, und ein Bild einer Abbildungslinse (302) für die Beschichtung (204, 310) erstellt wird.

15. Verfahren gemäß Anspruch 1, **gekennzeichnet durch** Messen auch der IR-Strahlung von Papier oder einer Platte während der AUS-Periode einer Belichtung (502), wenn die Beschichtung (204, 310) nicht mit IR-Strahlung belichtet wird, und Bestimmen der Temperatur von Papier oder einer Platte aus der gemessenen IR-Strahlung.

16. Vorrichtung zum Messen einer Papier- oder Plattenbeschichtung mittels IR-Strahlung, wobei die Beschichtung (204, 310) zumindest zwei Komponenten aufweist, wobei die Vorrichtung einen Detektor (208, 322) zum Messen von zumindest einer Komponente der Beschichtung (204, 310) durch Verwenden von MIR-Strahlung im Spektralband von 2500 nm bis 20000 nm und zumindest einer anderen Komponente durch Verwenden von NIR-Strahlung im Spektralband von 700 nm bis 2500 nm aufweist, oder einen ersten und einen zweiten Detektor (208, 210) aufweist, die eingerichtet sind, um gleichzeitig zumindest eine Komponente aus der Beschichtung (204, 310) durch Verwenden von NIR-Strahlung im Spektralband von 2500 nm bis 20000 nm zu messen, und zumindest eine andere Komponente durch Verwenden von NIR-Strahlung im Spektralband von 700 nm bis 2500 nm zu messen,

wobei die Vorrichtung aufweist:

eine optische Energiequelle (200, 300) zum Abstrahlen von IR-Strahlung auf die Beschichtung;
einen Chopper (202, 304, 400) zum Choppen der auf die Beschichtung (204, 310) gerichteten IR-Strahlung und zum Choppen der IR-Strahlung, die von der Beschichtung abgegeben wird, synchron mit der IR-Strahlung, die die Beschichtung belichtet; und
um eine MIR-Messung für die zumindest eine Komponente durchzuführen, weist die Vorrichtung auf:

einen Bandpassfilter (316, 406) in dem Chopper (202, 304, 400) zum Filtern eines MIR-Wellenlängenbandes, das bezüglich der Absorption der zumindest einen Komponente empfindlich ist, aus der von der Beschichtung abgegebenen IR-Strahlung;
wobei der eine Detektor (208, 322) oder der erste Detektor (208) eingerichtet ist, um MIR-Strahlung, die bezüglich der Absorption empfindlich ist, zu erfassen, und um die Stärke der erfassten MIR-Strahlung in ein elektrisches Signal gleicher Stärke umzuwandeln, mittels dessen Signals die Vorrichtung eingerichtet ist, um die Stärke der bezüglich der Absorption empfindlichen MIR-Strahlung zu messen;
einen Bandpassfilter (316, 412) in dem Chopper (402, 304, 400) zum Filtern eines MIR-Wellenlängenbandes, das bezüglich der Absorption der zumindest einen Komponente von der von der Beschichtung abgegebenen IR-Strahlung unempfindlich ist;
wobei der eine Detektor (208, 322) oder der erste Detektor (208) eingerichtet ist, um MIR-Strahlung, die bezüglich der Absorption unempfindlich ist, zu erfassen, und um die Stärke der erfassten MIR-Strahlung in ein elektrisches Signal gleicher Stärke umzuwandeln, mittels dessen Signals die Vorrichtung eingerichtet ist, um die Stärke der bezüglich der Absorption unempfindlichen MIR-Strahlung zu messen;
wobei die Vorrichtung eingerichtet ist, um die Stärke der Absorption der zumindest einen Komponente durch Vergleichen der Stärke der bezüglich der Absorption empfindlichen MIR-Strahlung und der Stärke der bezüglich der Absorption unempfindlichen MIR-Strahlung miteinander zu messen;
wobei die Vorrichtung eingerichtet ist, um die Menge der zumindest einen Komponente der Beschichtung auf der Basis der gemessenen Stärke der zumindest einen MIR-Absorption zu bestimmen; und
um eine NIR-Messung für die zumindest eine andere Komponente durchzuführen, weist die Vorrichtung auf:

einen Bandpassfilter (318, 408) in

dem Chopper (202, 304, 400) zum Filtern eines Wellenlängenbandes, das bezüglich der Absorption der zumindest einen anderen Komponente in der NIR-Region empfindlich ist, von der von der Beschichtung abgegebenen IR-Strahlung;
wobei der eine Detektor (208, 322) oder der zweite Detektor (210) eingerichtet ist, um NIR-Strahlung, die bezüglich der Absorption empfindlich ist, zu erfassen, und um die Stärke der erfassten NIR-Strahlung in ein elektrisches Signal gleicher Stärke umzuwandeln, mittels dessen Signals die Vorrichtung eingerichtet ist, um die Stärke der bezüglich der Absorption empfindlichen NIR-Strahlung zu messen;
einen Bandpassfilter (318, 414) in dem Chopper (202, 304, 400) zum Filtern eines Wellenlängenbandes, das bezüglich der Absorption der zumindest einen anderen Komponente in der NIR-Region unempfindlich ist, von der von der Beschichtung abgegebenen IR-Strahlung;
wobei der eine Detektor (208, 322) oder der zweite Detektor (210) eingerichtet ist, um NIR-Strahlung, die bezüglich der Absorption unempfindlich ist, zu erfassen, und um die Stärke der erfassten NIR-Strahlung in elektrisches Signal gleicher Stärke umzuwandeln, mittels dessen Signals die Vorrichtung eingerichtet ist, um die Stärke der bezüglich der Absorption unempfindlichen NIR-Strahlung zu messen;
wobei die Vorrichtung eingerichtet ist, um die Stärke der Absorption der zumindest einen anderen Komponente durch Vergleichen der Stärke der bezüglich der Absorption empfindlichen NIR-Strahlung und der Stärke der bezüglich der Absorption unempfindlichen NIR-Strahlung miteinander zu messen;
wobei die Vorrichtung eingerichtet ist, um die Menge der zumindest einen anderen Komponente der Beschichtung auf der Basis der gemessenen Stärke der zumindest einen NIR-Absorption zu bestimmen.

17. Vorrichtung gemäß Anspruch 16, **dadurch gekennzeichnet, dass** die Vorrichtung eingerichtet ist, um die von der Beschichtung, die sich von der Richtung der spektralen Reflexion unterscheidet, reflektierten Strahlung zu messen.

18. Vorrichtung gemäß Anspruch 16, **dadurch gekennzeichnet, dass** der Chopper (202, 304, 400) zum Choppen der die Beschichtung bestrahlenden IR-Strahlung und von der Beschichtung (204, 310) abgegebene IR-Strahlung ein plattenförmiger Chopper mit Zähnen (402) zum Verhindern eines Durchgangs von IR-Strahlung und Zahnlöchern (404) zum Ermöglichen eines Durchgangs von IR-Strahlung ist.

19. Vorrichtung gemäß Anspruch 16, **dadurch gekennzeichnet, dass** der plattenförmige Chopper (304, 400) MIR- und NIR-Filter (406, 408, 412, 414) als Bandpassfilter zum Ermöglichen eines Durchgangs von IR-Strahlung und Filterlücken (410) zum Verhindern eines Durchgangs von IR-Strahlung aufweist, wobei der plattenförmige Chopper (304, 400) eingerichtet ist, um die von der Beschichtung (204, 310) abgegebene IR-Strahlung zu choppen und zu bandpassfiltern.

20. Vorrichtung gemäß Anspruch 16, **dadurch gekennzeichnet, dass,** um die Operation der Vorrichtung zu kalibrieren, die Vorrichtung eingerichtet ist, um in sowohl der MIR- als auch der NIR-Region ein Messsignal U_i^{pap} zu messen, das proportional mit Intensität des i-ten Wellenlängenbandes der Papier- oder Plattenbeschichtung (204, 310) verläuft;

um ein Messsignal U_i^{ref} zu messen, das proportional zur Intensität des Referenzobjekts mit bekannten Eigenschaften in einem entsprechenden Wellenlängenband verläuft;
um die Absorptionsfähigkeit A_i des i-ten Wellenlängenbandes auf die folgende Weise zu bilden:

$$A_i = -log\left(\frac{U_i^{pap}}{U_i^{ref}}\right);$$

und

um die Menge der j-ten Komponente $\hat{C}^j$ wie folgt zu bilden:

$$\hat{C}^j = b^j_{offset} + \sum_{i=1}^{N} b_i^j A_i$$

wobei j der Index jeder Komponente ist, i der Index des bei der Messung verwendeten Wellenlängenbandes ist und Messungen in N Wellenlängenbändern durchgeführt werden, sodass i von 1 bis N verläuft.

21. Vorrichtung gemäß Anspruch 16, **dadurch gekennzeichnet, dass** die mittlere Wellenlänge des Bandpasses der MIR- und NIR-Filter (406, 408, 412, 414) durch Ändern des Neigungswinkels der Filter bezüglich der Richtung von IR-Strahlung, die die Filter durchdringt, anpassbar ist.

22. Vorrichtung gemäß Anspruch 16, **dadurch gekennzeichnet, dass** die Vorrichtung mehrere Vorrichtungseinheiten (608, 612, 618, 622, 628) aufweist, und wenn Papier oder eine Platte mehrere Male beschichtet wird, jede Vorrichtungseinheit eingerichtet ist, um eine Beschichtungsschicht vor und/oder nach jeder Beschichtungsoperation zu messen.

23. Vorrichtung gemäß Anspruch 16, **dadurch gekennzeichnet, dass** die Vorrichtung eingerichtet ist, um eine oder mehrere Beschichtungs- (204, 310) -Komponenten, wie etwa Kalziumcarbonat, Kaolin, Silizium und Wasser, durch Verwenden von MIR-Strahlung zu messen, und die Vorrichtung eingerichtet ist, um eine oder mehrere Komponenten, wie etwa Kaolin, Talkum, Gips, Latex, Stärke, Silizium und Wasser, durch Verwenden von NIR-Strahlung zu messen, und, wenn Wasser gemessen wird, die Vorrichtung eingerichtet ist, um den Feuchtigkeitsgehalt zu bestimmen.

24. Vorrichtung gemäß Anspruch 23, **dadurch gekennzeichnet, dass** wenn Kalziumcarbonat und Kaolin gemessen werden, die Vorrichtung eingerichtet ist, um die Absorption von Kalziumcarbonat in einem Wellenlängenband mit einer mittleren Wellenlänge von ungefähr 3950 nm mittels MIR-Strahlung zu messen, und die Vorrichtung eingerichtet ist, um die Absorption von Kaolin in einem Wellenlängenband mit einer mittleren Wellenlänge von ungefähr 2700 nm mittels MIR-Strahlung zu messen.

25. Vorrichtung gemäß Anspruch 23, **dadurch gekennzeichnet, dass** wenn Kaolin und Wasser gemessen werden, die Vorrichtung eingerichtet ist, um die Absorption von Kaolin in einem Wellenlängenband mit einer mittleren Wellenlänge von ungefähr 2208 nm mittels NIR-Strahlung zu messen, und die Vorrichtung eingerichtet ist, um die Absorption von Wasser in einem Wellenlängenband mit einer mittleren Wellenlänge von ungefähr 1940 nm mittels NIR-Strahlung zu messen.

26. Vorrichtung gemäß Anspruch 16, **dadurch gekennzeichnet, dass** in den mittels sowohl MIR- als auch NIR-Strahlung durchgeführten Messungen die Vorrichtung eingerichtet ist, um zumindest ein Wellenlängenband, das bezüglich der Absorption der Komponente unempfindlich ist, auf beiden Seiten des Absorptionswellenlängenbandes zu messen und, auf der Basis der gemessenen Ergebnisse, die Stärke der bezüglich der Absorption unempfindlichen Strahlung zu bilden und, um die Absorptionsstärke zu bestimmen, die Stärke der bezüglich der Absorption empfindlichen Strahlung und die gebildete Stärke der bezüglich der Absorption unempfindlichen Strahlung miteinander zu vergleichen.

27. Vorrichtung gemäß Anspruch 16, **dadurch gekennzeichnet, dass** in den mittels sowohl MIR- als auch NIR-Strahlung durchgeführten Messungen zum Messen der Absorption mittels der Strahlungsstärke, die Vorrichtung eingerichtet ist

um die auf die Beschichtung gerichtete IR-Strahlung zu choppen, sodass während der Belichtungszeit (504) die Beschichtung durch IR-Strahlung belichtet wird, und während der AUS-Periode der Belichtung (502, 506), die Beschichtung nicht durch IR-Strahlung belichtet wird;
um die von der Beschichtung abgegebene IR-Strahlung zu choppen, sodass während der Erfassungszeit (510) der Strahlung von der Beschichtung ermöglicht wird, die Messung zu durchlaufen, wobei die Erfassungszeit länger ist als die Belichtungszeit (504), und während der AUS-Periode der Erfassung (508, 512) die Strahlung von der Beschichtung gehindert wird, die Messung zu durchlaufen;
wenn die von der Beschichtung abgegebene Strahlung die Messung während der Erfassungszeit (510) durchläuft, bevor die Belichtungszeit (504) beginnt, ein erstes Interferenzniveau der Beschichtung zu messen;
wenn von der Beschichtung abgegebene Strahlung die Messung während der Erfassungszeit (510) durchläuft und die Beschichtung während der Belichtungszeit (504) gleichzeitig belichtet wird, die Stärke der Gesamtstrahlung, die sowohl die Interferenz als auch die zu messende Strahlung aufweist, zu messen;
wenn von der Beschichtung abgegebene Strahlung die Messung während der Erfassungszeit (510) durchläuft, nachdem die Belichtungszeit (504) geendet ist, ein zweites Interferenzniveau der Beschichtung zu messen;
um das Interferenzniveau aus dem Mittelwert der ersten und zweiten Interferenz zu bilden; und
um das gemittelte Interferenzniveau von der Stärke der Gesamtstrahlung zu subtrahieren.

28. Vorrichtung gemäß Anspruch 16, **dadurch gekennzeichnet, dass** die Vorrichtung eingerichtet ist, um ein Bild von IR-Strahlung der Oberfläche, die die IR-Strahlung abgibt, für den choppenden Chopper

(202, 304, 400) zu bilden, und ein Bild einer Abbildungslinse (302) für die Beschichtung (204, 310) zu bilden.

29. Vorrichtung gemäß Anspruch 16, **dadurch gekennzeichnet, dass** die Vorrichtung ebenso eingerichtet ist, um die IR-Strahlung von Papier oder einer Platte während der AUS-Periode der Belichtung (502) zu messen, wenn die Beschichtung (204, 310) nicht mit IR-Strahlung belichtet wird, und die Vorrichtung eingerichtet ist, um die Temperatur von Papier oder einer Platte aus der gemessenen IR-Strahlung zu bestimmen.

Revendications

1. Procédé de mesure d'un revêtement de papier ou de carton au moyen d'un rayonnement IR, le revêtement (204, 310) comprenant au moins deux composants, le procédé comprenant :

par un détecteur (208, 322) ou simultanément par deux détecteurs respectifs (208, 210)
la mesure d'au moins un composant du revêtement (204, 310) en utilisant un rayonnement IR moyen dans la bande spectrale allant de 2500 nm à 20 000 nm et d'au moins un autre composant en utilisant un rayonnement IR proche dans la bande spectrale allant de 700 nm à 2500 nm, et, afin de mesurer l'au moins un composant en utilisant un rayonnement IR moyen :

le fait de diriger le rayonnement IR sur le revêtement (204, 310) ;
le hachage, par un hacheur (202, 304, 400), du rayonnement IR dirigé sur le revêtement (204, 310) ;
le hachage, par le hacheur (202, 304, 400), du rayonnement IR émergeant du revêtement (204, 310) de manière synchrone avec le rayonnement IR éclairant le revêtement ;
le filtrage passe-bande, par un filtre (316, 406) du hacheur (202, 304, 400), d'une bande de longueurs d'onde d'IR moyen qui est sensible à l'absorption dudit au moins un composant provenant du rayonnement IR émergeant du revêtement (204, 310),
la mesure de la puissance du rayonnement IR moyen sensible à l'absorption ;
le filtrage passe-bande, par un filtre (412) du hacheur (202, 304, 400), d'une bande de longueurs d'onde d'IR moyen qui est insensible à l'absorption dudit au moins un composant provenant du rayonnement IR émergeant du revêtement (204, 310),
la mesure de la puissance du rayonnement IR moyen insensible à l'absorption ;
la mesure de la puissance de l'absorption de l'IR moyen de l'au moins un composant par comparaison de la puissance du rayonnement IR moyen sensible à l'absorption et de la puissance du rayonnement IR moyen insensible à l'absorption l'une à l'autre ;
la détermination de la quantité de l'au moins un composant du revêtement (204, 310) sur la base de la puissance mesurée de l'absorption de l'IR moyen ; et,

afin de mesurer l'au moins un autre composant en utilisant un rayonnement IR proche :

le filtrage passe bande, par un filtre (318, 408) du hacheur (202, 304, 400), d'une bande de longueurs d'onde d'IR proche qui est sensible à l'absorption de l'au moins un autre composant provenant du rayonnement IR émergeant du revêtement (204, 310),
la mesure de la puissance du rayonnement IR proche sensible à l'absorption ;
le filtrage passe-bande, par un filtre (414) du hacheur (202, 304, 400), d'une bande de longueurs d'onde d'IR proche qui est insensible à l'absorption de l'au moins un autre composant provenant du rayonnement IR émergeant du revêtement (204, 310),
la mesure de la puissance du rayonnement IR proche insensible à l'absorption ;
la mesure de la puissance de l'absorption de l'IR proche de l'au moins un autre composant par comparaison de la puissance du rayonnement IR proche sensible à l'absorption et de la puissance du rayonnement IR proche insensible à l'absorption l'une à l'autre ; et
la détermination de la quantité de l'au moins un autre composant du revêtement (204, 310) sur la base de la puissance mesurée de l'absorption de l'IR proche.

2. Procédé selon la revendication 1, **caractérisé par** la mesure des rayonnements IR moyen et IR proche au moyen de détecteurs séparés.

3. Procédé selon la revendication 1, **caractérisé par** la réalisation de la mesure dans le procédé à partir du rayonnement réfléchi par le revêtement (204, 310) dans la direction de mesure, qui est différente de la direction de la réflexion spéculaire.

4. Procédé selon la revendication 1, **caractérisé par** le hachage du rayonnement IR éclairant le revêtement (204, 310) et du rayonnement IR émergeant du revêtement avec un hacheur de type disque (304, 400) comprenant des dents (402) pour empêcher le rayonnement IR de passer, et des espaces entre les dents (404) pour permettre au rayonnement IR de passer.

5. Procédé selon la revendication 1, **caractérisé par** le hachage et le filtrage passe-bande du rayonnement IR émergeant du revêtement (204, 310) avec un hacheur de type disque (304, 400) comprenant des filtres d'IR moyen et d'IR proche (406, 408) pour permettre au rayonnement IR de passer, et des espaces (410) entre les filtres (406, 408) pour empêcher le rayonnement IR de passer.

6. Procédé selon la revendication 1, **caractérisé par**, afin d'étalonner l'opération du procédé à la fois dans la région d'IR moyen et d'IR proche, la mesure d'un signal de mesures U_i^{pap} qui est proportionnel à l'intensité de la i^{ème} bande de longueurs d'onde du revêtement de papier ou de carton (204, 310) ;
la mesure d'un signal de mesure i qui est proportionnel à l'intensité de l'objet de référence ayant des propriétés connues à une bande de longueurs d'onde correspondante ;
la formation de l'absorbance A_i de la i^{ème} bande de longueurs d'onde de la manière suivante :

$$A_i = -\log\left(\frac{U_i^{pap}}{U_i^{ref}}\right);$$ et

la formation de la quantité du j^{ème} composant $\hat{C}^j$ comme suit :

$$\hat{C}^j = b_{offset}^j + \sum_{i=1}^{N} b_i^j A_i ,$$

où j est l'indice de chaque composant, i est l'indice de la bande de longueurs d'onde utilisée lors de la mesure et les mesures sont réalisées à N bandes de longueurs d'onde de façon que i aille de 1 à N.

7. Procédé selon la revendication 1, **caractérisé par** l'ajustement de la longueur d'onde médiane de la bande passante des filtres d'IR moyen et d'IR proche (406, 408) par l'angle d'inclinaison des filtres (406, 408) par rapport à la direction du rayonnement IR pénétrant dans les filtres.

8. Procédé selon la revendication 1, **caractérisé en ce que**, quand le papier ou le carton est revêtu plusieurs fois, la mesure du procédé est réalisée avant et/ou après le revêtement pour mesurer la couche de revêtement.

9. Procédé selon la revendication 1, **caractérisé par** la mesure d'un ou de plusieurs composants de revêtement (204, 310), comme le carbonate de calcium, le kaolin, le silicium et l'eau, en utilisant un rayonnement IR moyen, et la mesure d'un ou de plusieurs composants, comme le kaolin, le talc, le gypse, le latex, l'amidon, le silicium et l'eau, en utilisant un rayonnement IR proche, et, quand de l'eau est mesurée, la détermination de la teneur en humidité.

10. Procédé selon la revendication 9, **caractérisé en ce que**, quand du carbonate de calcium et du kaolin sont mesurés au moyen d'un rayonnement IR moyen, l'absorption de carbonate de calcium est mesurée à une bande de longueurs d'onde présentant une longueur d'onde médiane d'environ 3950 nm, et l'absorption de kaolin est mesurée au moyen d'un rayonnement IR moyen à une bande de longueurs d'onde présentant une longueur d'onde médiane d'environ 2700 nm.

11. Procédé selon la revendication 9, **caractérisé en ce que**, quand du kaolin et de l'eau sont mesurés au moyen d'un rayonnement IR proche, l'absorption de kaolin est mesurée à une bande de longueurs d'onde présentant une longueur d'onde médiane d'environ 2208 nm, et l'absorption d'eau est mesurée au moyen d'un rayonnement IR proche à une bande de longueurs d'onde présentant une longueur d'onde médiane d'environ 1940 nm.

12. Procédé selon la revendication 1, **caractérisé en ce que** lors des mesures réalisées à la fois au moyen des rayonnements IR moyen et IR proche, au moins une bande de longueurs d'onde (108, 110, 120, 122) insensible à l'absorption du composant est mesurée des deux côtés de la bande de longueurs d'onde d'absorption (106, 118) et sur la base des résultats mesurés, la puissance du rayonnement insensible à l'absorption est formée, et, afin de déterminer la puissance d'absorption, la puissance du rayonnement sensible à l'absorption et la puissance formée du rayonnement insensible à l'absorption sont comparées l'une à l'autre.

13. Procédé selon la revendication 1, **caractérisé par**, lors de la mesure réalisée à la fois au moyen des rayonnements IR moyen et IR proche pour mesurer l'absorption au moyen de la puissance de rayonnement,
le hachage du rayonnement IR dirigé sur le revêtement de façon que pendant le temps d'éclairage (504), le revêtement (204, 310) soit éclairé par le rayonnement IR et que pendant la période sans

éclairage (502, 506), le revêtement (204, 310) ne soit pas éclairé par le rayonnement IR ;
le filtrage passe-bande du rayonnement IR émergeant du revêtement de façon que pendant le temps de détection (510), le rayonnement provenant du revêtement puisse passer vers la mesure, le temps de détection étant plus long que le temps d'éclairage (504), et que pendant la période sans détection (508, 512), le rayonnement provenant du revêtement soit empêché de passer vers la mesure ;
quand le rayonnement émergeant du revêtement est passé vers la mesure pendant le temps de détection (510) avant que le temps d'éclairage (504) commence, la mesure d'un premier niveau d'interférence du revêtement ;
quand le rayonnement émergeant du revêtement est passé vers la mesure pendant le temps de détection (510) et que le revêtement est éclairé pendant le temps d'éclairage (504) simultanément, la mesure de la puissance du rayonnement total comprenant à la fois l'interférence et le rayonnement à mesurer ;
quand le rayonnement émergeant du revêtement est passé vers la mesure pendant le temps de détection (510) après que le temps d'éclairage (504) se termine, la mesure d'un second niveau d'interférence du revêtement ;
la formation du niveau d'interférence à partir de la valeur moyenne de la première et de la seconde interférence ; et
la soustraction du niveau d'interférence moyenné de la puissance du rayonnement total.

14. Procédé selon la revendication 1, **caractérisé par** le fait de diriger un rayonnement IR sur le revêtement (204, 310) de façon qu'une image de la surface émettant le rayonnement IR soit prise pour le hacheur de hachage (304, 400) et qu'une image d'une lentille d'imagerie (302) soit prise pour le revêtement (204, 310).

15. Procédé selon la revendication 1, **caractérisé** également par la mesure du rayonnement IR du papier ou du carton pendant la période sans éclairage (502) quand le revêtement (204, 310) n'est pas éclairé avec le rayonnement IR, et la détermination de la température du papier ou du carton à partir du rayonnement IR mesuré.

16. Appareil de mesure d'un revêtement de papier ou de carton au moyen d'un rayonnement IR, le revêtement (204, 310) comprenant au moins deux composants, l'appareil comprenant un détecteur (208, 322) pour mesurer au moins un composant du revêtement (204, 310) en utilisant un rayonnement IR moyen dans la bande spectrale allant de 2500 nm à 20 000 nm et au moins un autre composant en utilisant un rayonnement IR proche dans la bande spectrale allant de 700 nm à 2500 nm, ou des premier et second détecteurs (208, 210) conçus pour mesurer simultanément au moins un composant du revêtement (204, 310) en utilisant un rayonnement IR moyen dans la bande spectrale allant de 2500 nm à 20 000 nm et au moins un autre composant en utilisant un rayonnement IR proche dans la bande spectrale allant de 700 nm à 2500 nm,
l'appareil comprenant :

une source d'énergie optique (200, 300) pour irradier un rayonnement IR sur le revêtement ;
un hacheur (202, 304, 400) pour hacher le rayonnement IR dirigé sur le revêtement (204, 310) et pour hacher le rayonnement IR émergeant du revêtement de manière synchrone avec le rayonnement IR éclairant le revêtement ; et
afin de réaliser la mesure de l'IR moyen pour l'au moins un composant l'appareil comprend :

un filtre passe-bande (316, 406) dans le hacheur (202, 304, 400) pour filtrer une bande de longueurs d'onde d'IR moyen qui est sensible à l'absorption de l'au moins un composant provenant du rayonnement IR émergeant du revêtement ;
l'unique détecteur (208, 322) ou le premier détecteur (208) conçu pour détecter le rayonnement IR moyen sensible à l'absorption et pour convertir la puissance du rayonnement IR moyen détecté en signal électrique de puissance égale, au moyen duquel signal l'appareil est conçu pour mesurer la puissance du rayonnement IR moyen sensible à l'absorption ;
un filtre passe-bande (316, 406) dans le hacheur (202, 304, 400) pour filtrer une bande de longueurs d'onde d'IR moyen qui est insensible à l'absorption de l'au moins un composant provenant du rayonnement IR émergeant du revêtement ;
l'unique détecteur (208, 322) ou le premier détecteur (208) conçu pour détecter le rayonnement IR moyen insensible à l'absorption et pour convertir la puissance du rayonnement IR moyen détecté en signal électrique de puissance égale, au moyen duquel signal l'appareil est conçu pour mesurer la puissance du rayonnement IR moyen insensible à l'absorption ;
l'appareil étant conçu pour mesurer la puissance de l'absorption de l'au moins un composant par comparaison de la puissance du rayonnement IR moyen sensible à l'absorption et de la puissance du rayonnement IR moyen insensible à l'absorption l'une à l'autre ;
l'appareil étant conçu pour déterminer la

quantité de l'au moins un composant du revêtement sur la base de la puissance mesurée de l'au moins une absorption de l'IR moyen ;
et, afin de réaliser la mesure de l'IR proche pour l'au moins un autre composant l'appareil comprend :

un filtre passe-bande (318, 408) dans le hacheur (202, 304, 400) pour filtrer une bande de longueurs d'onde qui est sensible à l'absorption dudit au moins un autre composant dans la région d'IR proche provenant du rayonnement IR émergeant du revêtement ;
l'unique détecteur (208, 322) ou le second détecteur (210) conçu pour détecter le rayonnement IR proche sensible à l'absorption et pour convertir la puissance du rayonnement IR proche détecté en signal électrique de puissance égale, au moyen duquel signal l'appareil est conçu pour mesurer la puissance du rayonnement IR proche sensible à l'absorption ;
un filtre passe-bande (318, 414) dans le hacheur (202, 304, 400) pour filtrer une bande de longueurs d'onde qui est insensible à l'absorption dudit au moins un autre composant dans la région d'IR proche provenant du rayonnement IR émergeant du revêtement; l'unique détecteur (208, 322) ou le second détecteur (210) conçu pour détecter le rayonnement IR proche insensible à l'absorption et pour convertir la puissance du rayonnement IR proche détecté en signal électrique de puissance égale, au moyen duquel signal l'appareil est conçu pour mesurer la puissance du rayonnement IR proche insensible à l'absorption ;
l'appareil étant conçu pour mesurer la puissance de l'absorption de l'au moins un autre composant par comparaison de la puissance du rayonnement IR proche sensible à l'absorption et de la puissance du rayonnement IR proche insensible à l'absorption l'une à l'autre ;
l'appareil étant conçu pour déterminer la quantité de l'au moins un autre composant du revêtement sur la base de la puissance mesurée de l'au moins une absorption de l'IR proche.

17. Appareil selon la revendication 16, **caractérisé en ce que** l'appareil est conçu pour mesurer le rayonnement réfléchi par le revêtement dans la direction de mesure, qui est différente de la direction de la réflexion spéculaire.

18. Appareil selon la revendication 16, **caractérisé en ce que** le hacheur (202, 304, 400) servant à hacher le rayonnement IR éclairant le revêtement et le rayonnement IR émergeant du revêtement (204, 310) est un hacheur de type disque comprenant des dents (402) pour empêcher le rayonnement IR de passer, et des espaces (404) entre les dents pour permettre au rayonnement IR de passer.

19. Appareil selon la revendication 16, **caractérisé en ce que** le hacheur de type disque (304, 400) comprend des filtres d'IR moyen et d'IR proche (406, 408, 412, 414) en tant que filtres passe-bande pour permettre au rayonnement IR de passer, et des espaces (410) entre les filtres pour empêcher le rayonnement IR de passer, moyennant quoi le hacheur type disque (304, 400) est conçu pour hacher et soumettre à un filtrage passe-bande le rayonnement IR émergeant du revêtement (204, 310).

20. Appareil selon la revendication 16, **caractérisé en ce que**, afin d'étalonner le fonctionnement de l'appareil, l'appareil est conçu pour mesurer à la fois dans la région d'IR moyen et d'IR proche un signal de mesure U_i^{pap} qui est proportionnel à l'intensité de la $i^{ème}$ bande de longueurs d'onde du revêtement de papier ou de carton (204, 310) ;

pour mesurer un signal de mesure U_i^{ref} qui est proportionnel à l'intensité de l'objet de référence ayant des propriétés connues à une bande de longueurs d'onde correspondante ;
pour former l'absorbance A_i de la $i^{ème}$ bande de longueurs d'onde de la manière suivante :

$$A_i = -\log\left(\frac{U_i^{pap}}{U_i^{ref}}\right);$$ et

pour former la quantité du $j^{ième}$ composant $\hat{C}^j$ comme suit :

$$\hat{C}^j = b_{offset}^j + \sum_{i=1}^{N} b_i^j A_i,$$

où j est l'indice de chaque composant, i est l'indice de la bande de longueurs d'onde utilisée lors de la mesure, et les mesures sont réalisées à N bandes de longueurs d'onde de façon que i aille de 1 à N.

21. Appareil selon la revendication 16, **caractérisé en ce que** la longueur d'onde médiane de la bande passante des filtres d'IR moyen et d'IR proche (406, 408, 412, 414) est ajustable en modifiant l'angle d'inclinaison des filtres par rapport à la direction du rayonnement IR pénétrant dans les filtres.

22. Appareil selon la revendication 16, **caractérisé en ce que** l'appareil comprend plusieurs unités d'appareil (608, 612, 618, 622, 628) et quand le papier ou le carton est revêtu plusieurs fois, chaque unité d'appareil est conçue pour mesurer une couche de revêtement avant et/ou après chaque opération de revêtement.

23. Appareil selon la revendication 16, **caractérisé en ce que** l'appareil est conçu pour mesurer un ou plusieurs composants du revêtement (204, 310), comme le carbonate de calcium, le kaolin, le silicium et l'eau, en utilisant un rayonnement IR moyen, et l'appareil est conçu pour mesurer un ou plusieurs composants, comme le kaolin, le talc, le gypse, le latex, l'amidon, le silicium et l'eau, en utilisant un rayonnement IR proche, et, quand l'eau est mesurée, l'appareil est conçu pour déterminer la teneur en humidité.

24. Appareil selon la revendication 23, **caractérisé en ce que**, quand du carbonate de calcium et du kaolin sont mesurés, l'appareil est conçu pour mesurer l'absorption de carbonate de calcium à une bande de longueurs d'onde présentant une longueur d'onde médiane d'environ 3950 nm au moyen d'un rayonnement IR moyen, et l'appareil est conçu pour mesurer l'absorption de kaolin à une bande de longueurs d'onde présentant une longueur d'onde médiane d'environ 2700 nm au moyen d'un rayonnement IR moyen.

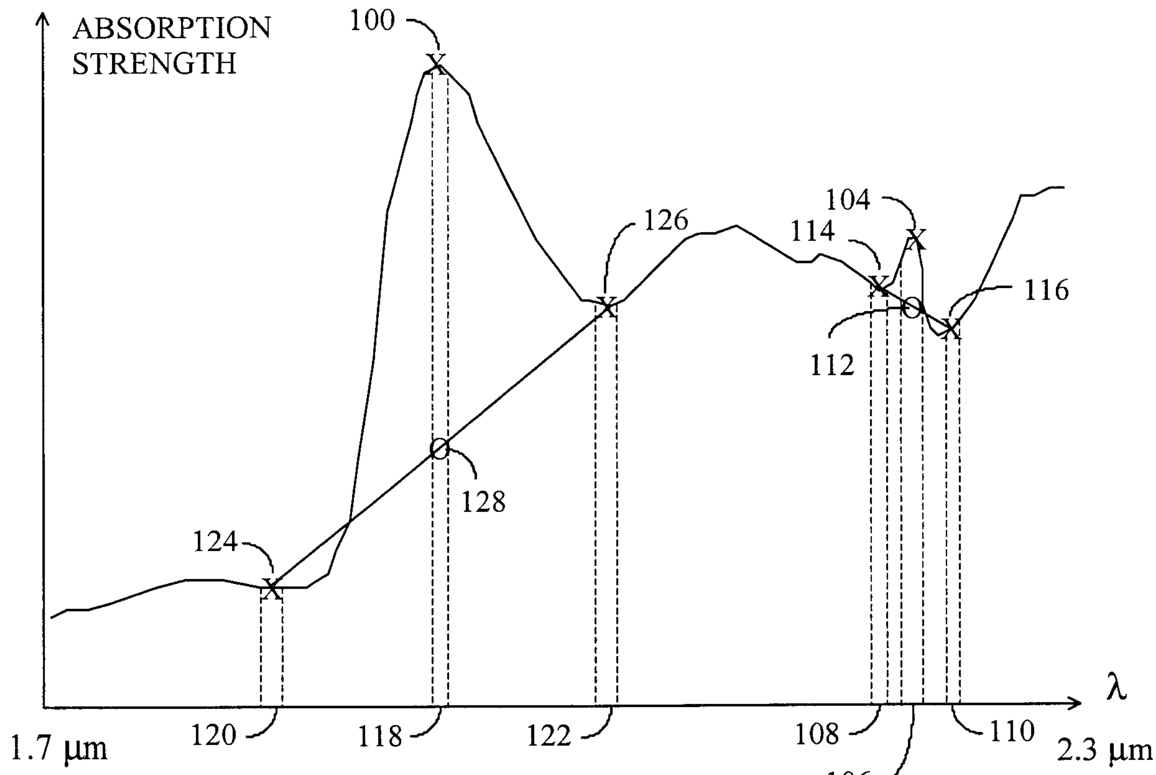
25. Appareil selon la revendication 23, **caractérisé en ce que** quand du kaolin et de l'eau sont mesurés, l'appareil est conçu pour mesurer l'absorption de kaolin à une bande de longueurs d'onde présentant une longueur d'onde médiane d'environ 2208 nm au moyen d'un rayonnement IR proche, et l'appareil est conçu pour mesurer l'absorption d'eau à une bande de longueurs d'onde présentant une longueur d'onde médiane d'environ 1940 nm au moyen d'un rayonnement IR proche.

26. Appareil selon la revendication 16, **caractérisé en ce que** lors des mesures réalisées à la fois au moyen des rayonnements IR moyen et IR proche, l'appareil est conçu pour mesurer au moins une bande de longueurs d'onde insensible à l'absorption du composant des deux côtés de la bande de longueurs d'onde d'absorption et pour former, sur la base des résultats mesurés, la puissance du rayonnement insensible à l'absorption, et, afin de déterminer la puissance d'absorption, pour comparer la puissance du rayonnement sensible à l'absorption et la puissance formée du rayonnement insensible à l'absorption l'une à l'autre.

27. Appareil selon la revendication 16, **caractérisé en ce que** lors des mesures réalisées à la fois au moyen des rayonnements IR moyen et IR proche pour mesurer l'absorption au moyen de la puissance de rayonnement, l'appareil est conçu
pour hacher le rayonnement IR dirigé sur le revêtement de façon que pendant le temps d'éclairage (504), le revêtement soit éclairé par le rayonnement IR et que pendant la période sans éclairage (502, 506), le revêtement ne soit pas éclairé par le rayonnement IR ;
pour hacher le rayonnement IR émergeant du revêtement de façon que pendant le temps de détection (510), le rayonnement provenant du revêtement puisse passer vers la mesure, le temps de détection étant plus long que le temps d'éclairage (504), et que pendant la période sans détection (508, 512), le rayonnement provenant du revêtement soit empêché de passer vers la mesure ;
quand le rayonnement émergeant du revêtement est passé vers la mesure pendant le temps de détection (510) avant que le temps d'éclairage (504) commence, pour mesurer un premier niveau d'interférence du revêtement ;
quand le rayonnement émergeant du revêtement est passé vers la mesure pendant le temps de détection (510) et que le revêtement est éclairé pendant le temps d'éclairage (504) simultanément, pour mesurer la puissance du rayonnement total comprenant à la fois l'interférence et le rayonnement à mesurer ;
quand le rayonnement émergeant du revêtement est passé vers la mesure pendant le temps de détection (510) après que le temps d'éclairage (504) se termine, pour mesurer un second niveau d'interférence du revêtement ;
pour former le niveau d'interférence à partir de la valeur moyenne de la première et de la seconde interférence ; et
pour soustraire le niveau d'interférence moyenné de la puissance du rayonnement total.

28. Appareil selon la revendication 16, **caractérisé en ce que** l'appareil est conçu pour prendre une image du rayonnement IR de la surface émettant le rayonnement IR pour le hacheur de hachage (202, 304, 400) et une image d'une lentille d'imagerie (302) pour le revêtement (204, 310).

29. Appareil selon la revendication 16, **caractérisé en ce que** l'appareil est également conçu pour mesurer le rayonnement IR du papier ou du carton pendant la période sans éclairage (502), quand le revêtement (204, 310) n'est pas éclairé avec le rayonnement IR, et l'appareil est conçu pour déterminer la température du papier ou du carton à partir du rayonnement IR mesuré.


ABSORPTION
STRENGTH
100
104
114
126
116
112
128
124
λ
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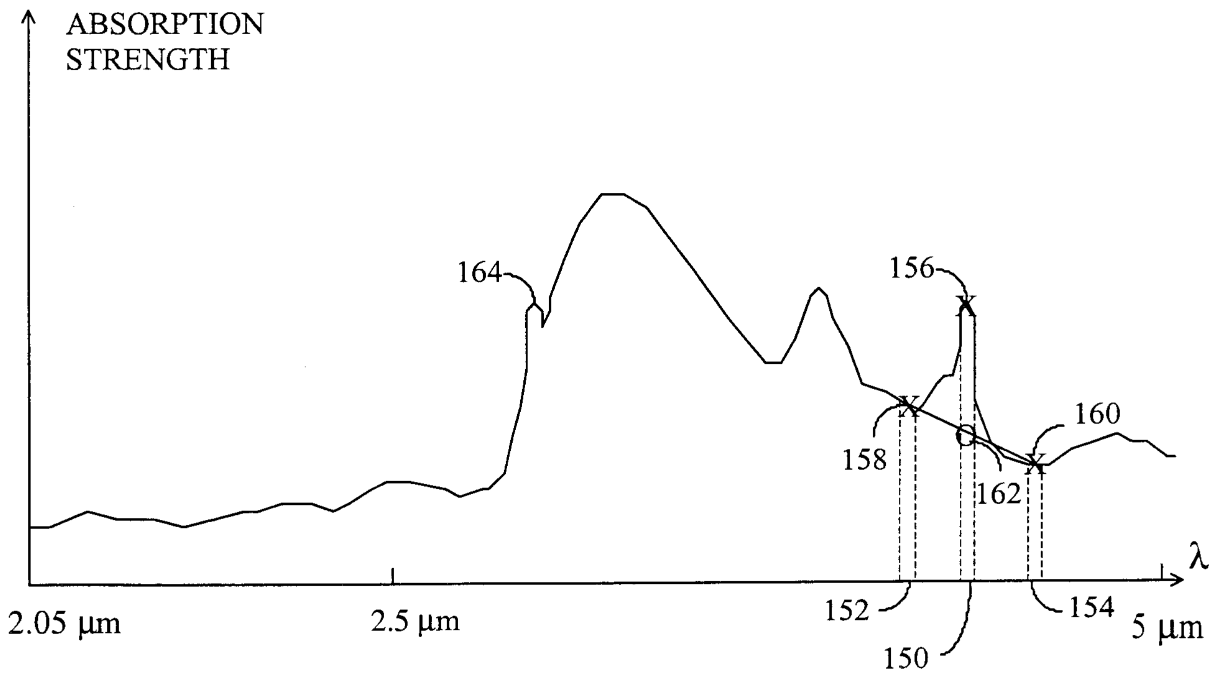
120
118
122
108
106
110
2.3 μm

FIG. 1A


ABSORPTION
STRENGTH
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156
158
160
162
λ
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2.5 μm
152
150
154
5 μm

FIG. 1B

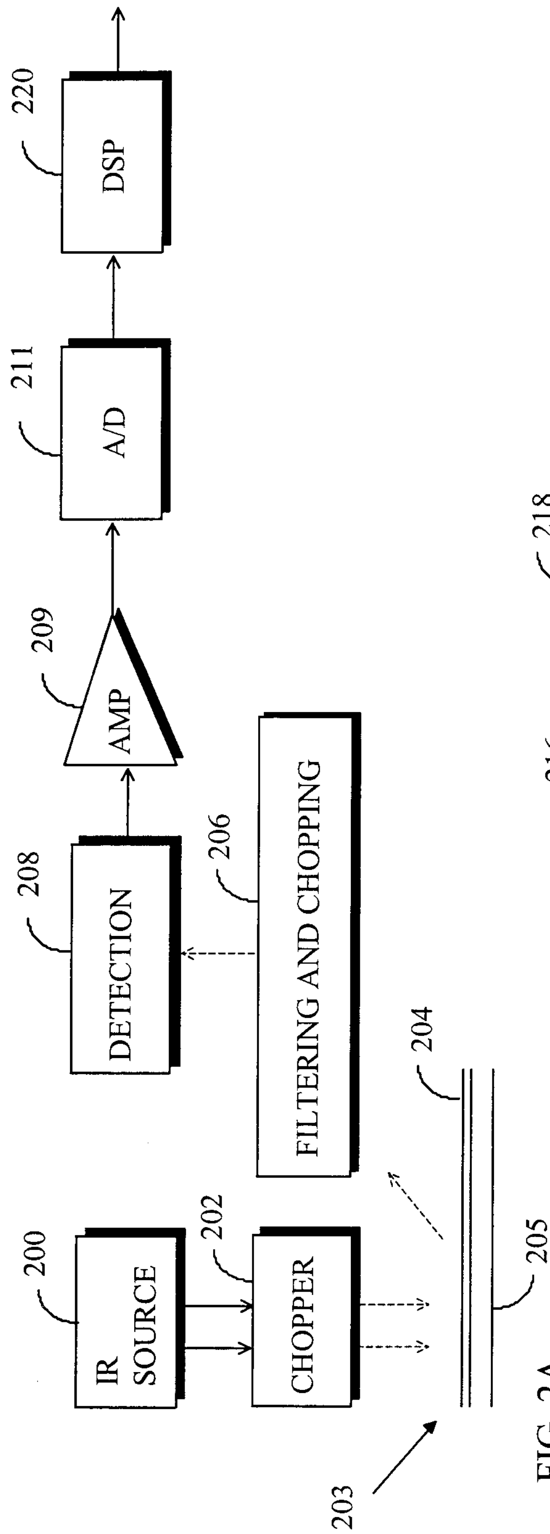
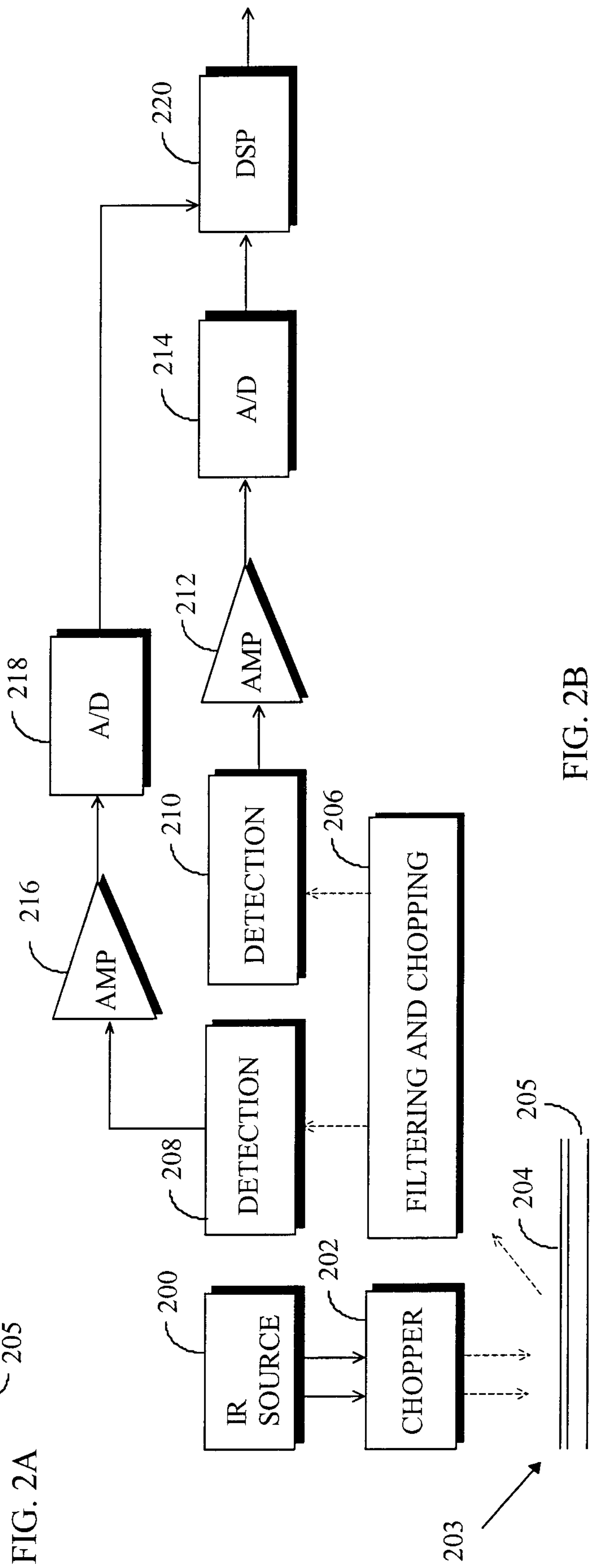

IR SOURCE
200
CHOPPER
202
FILTERING AND CHOPPING
206
DETECTION
208
AMP
209
A/D
211
DSP
220
203
204
205

FIG. 2A


IR SOURCE
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CHOPPER
202
FILTERING AND CHOPPING
206
DETECTION
208
DETECTION
210
AMP
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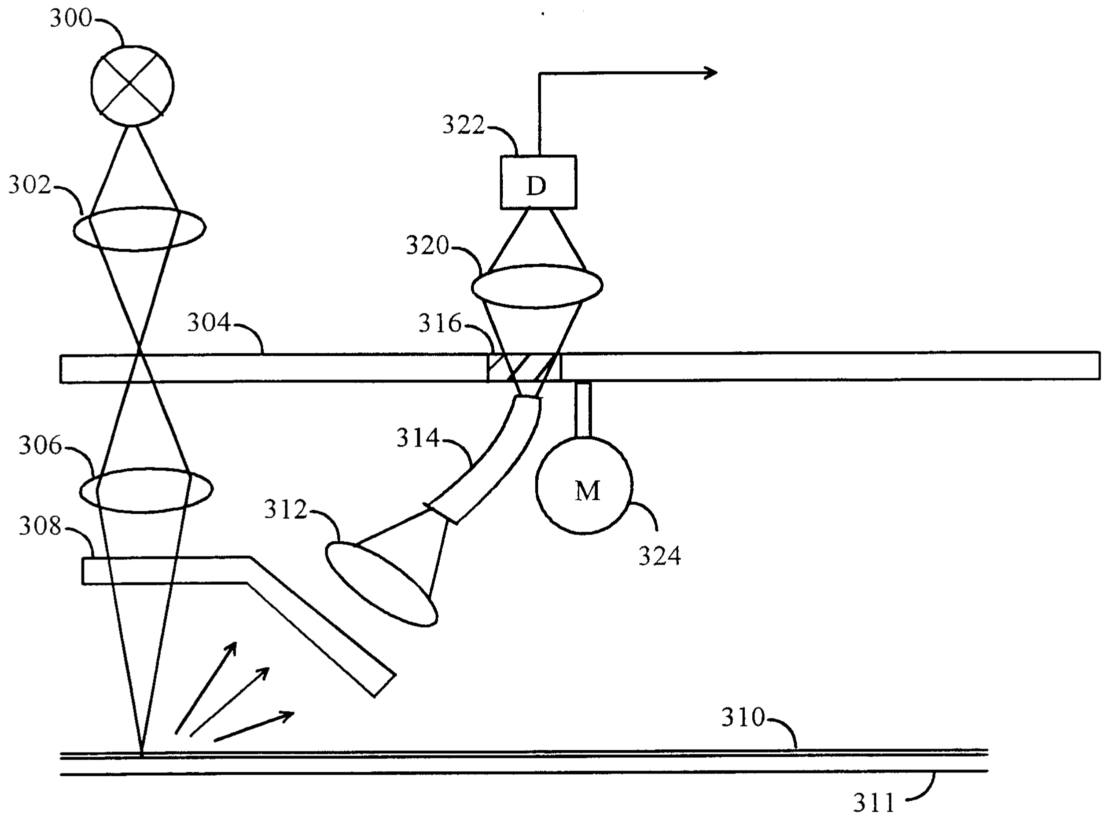
AMP
212
A/D
218
A/D
214
DSP
220
203
204
205

FIG. 2B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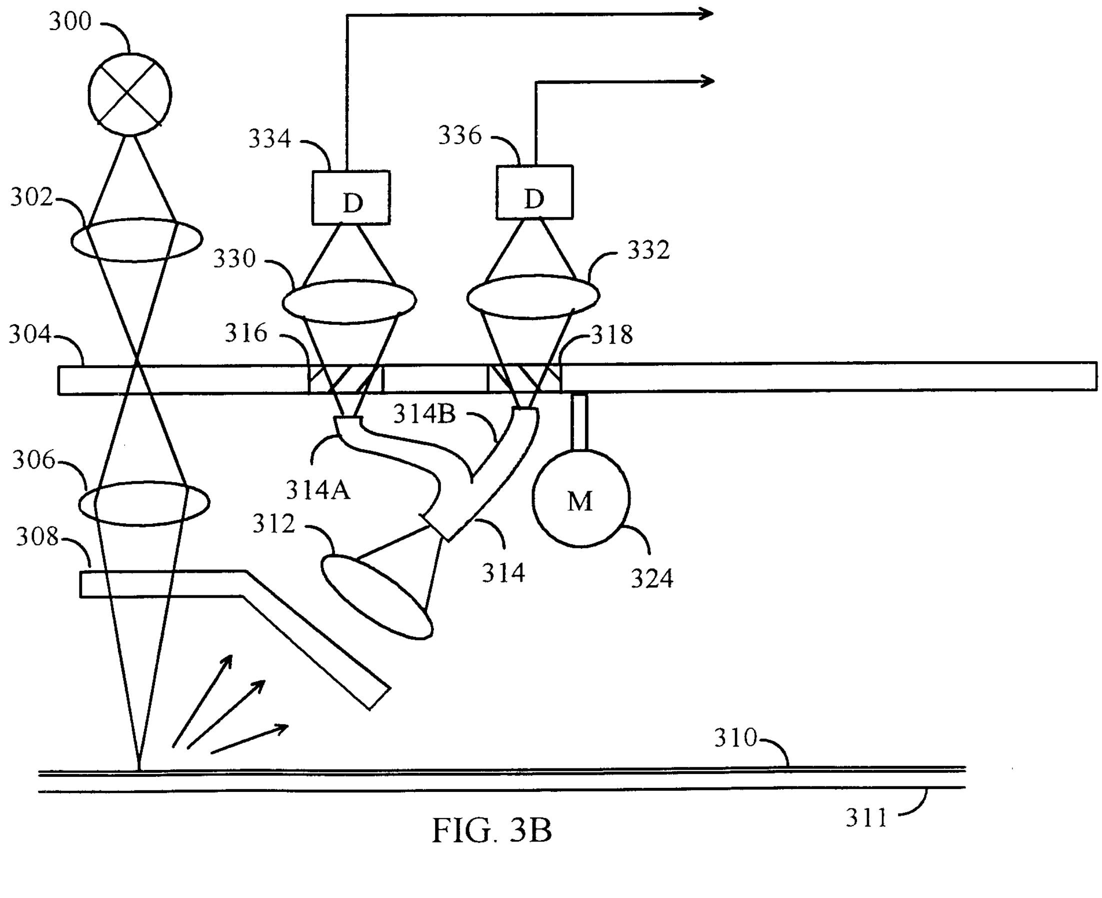
302
304
306
308
310
311
312
314
316
320
322
D
M
324

FIG. 3A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302
304
306
308
310
311
312
314
314A
314B
316
318
330
332
334
336
D
D
M
324

FIG. 3B

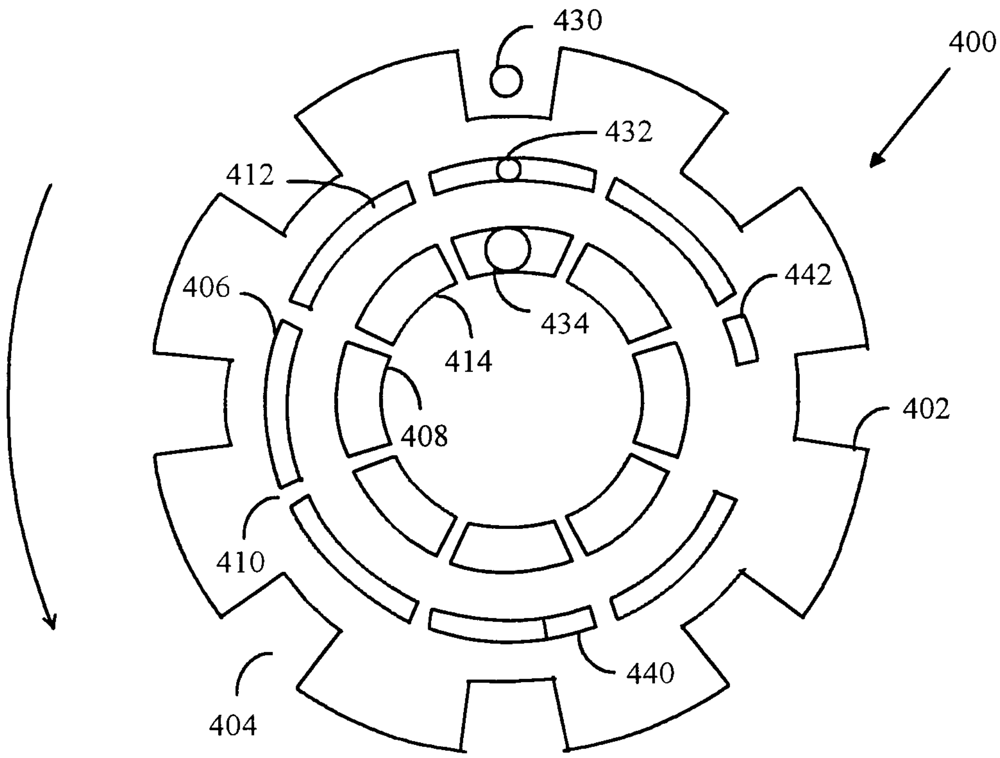


FIG. 4

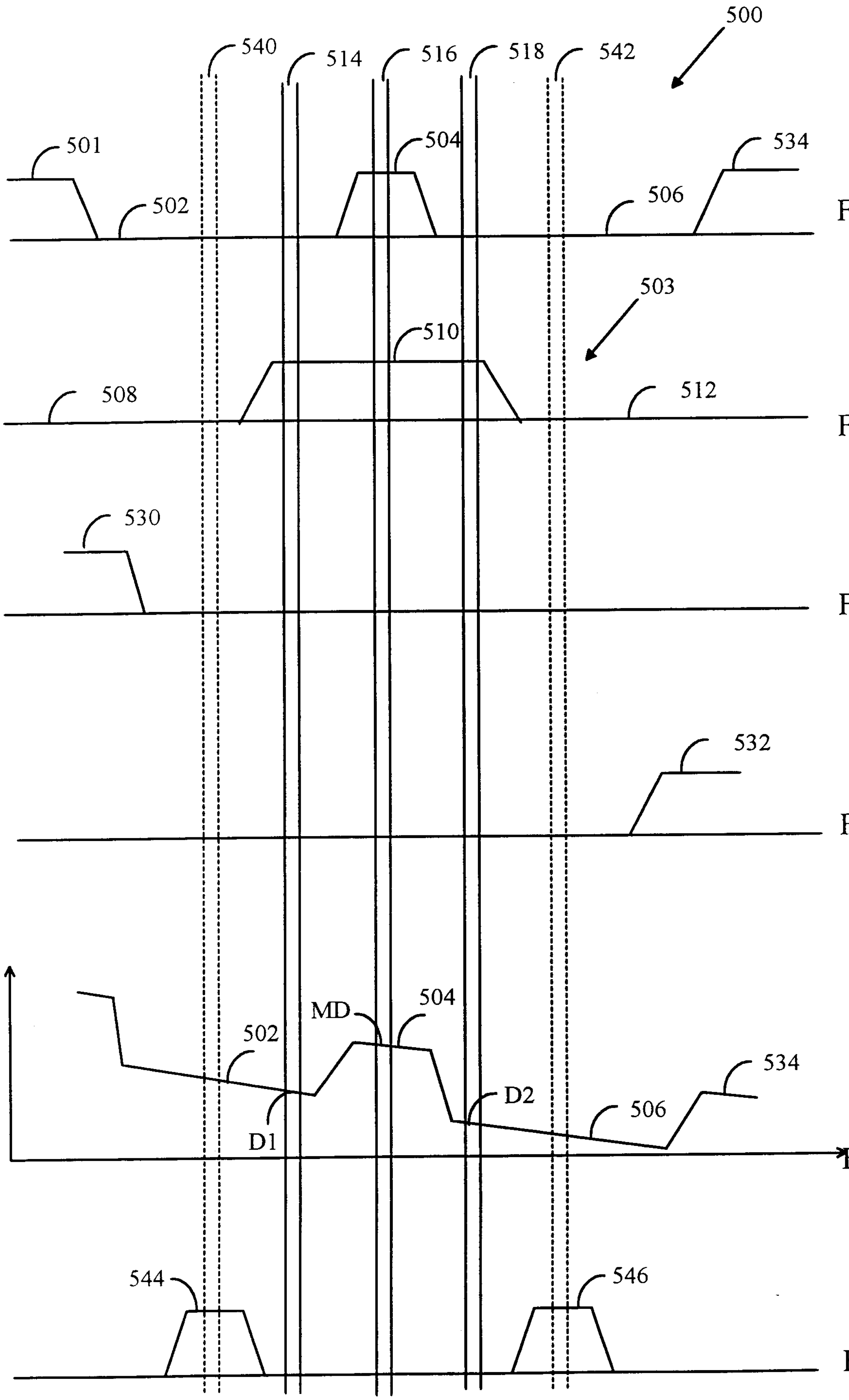


FIG. 5A

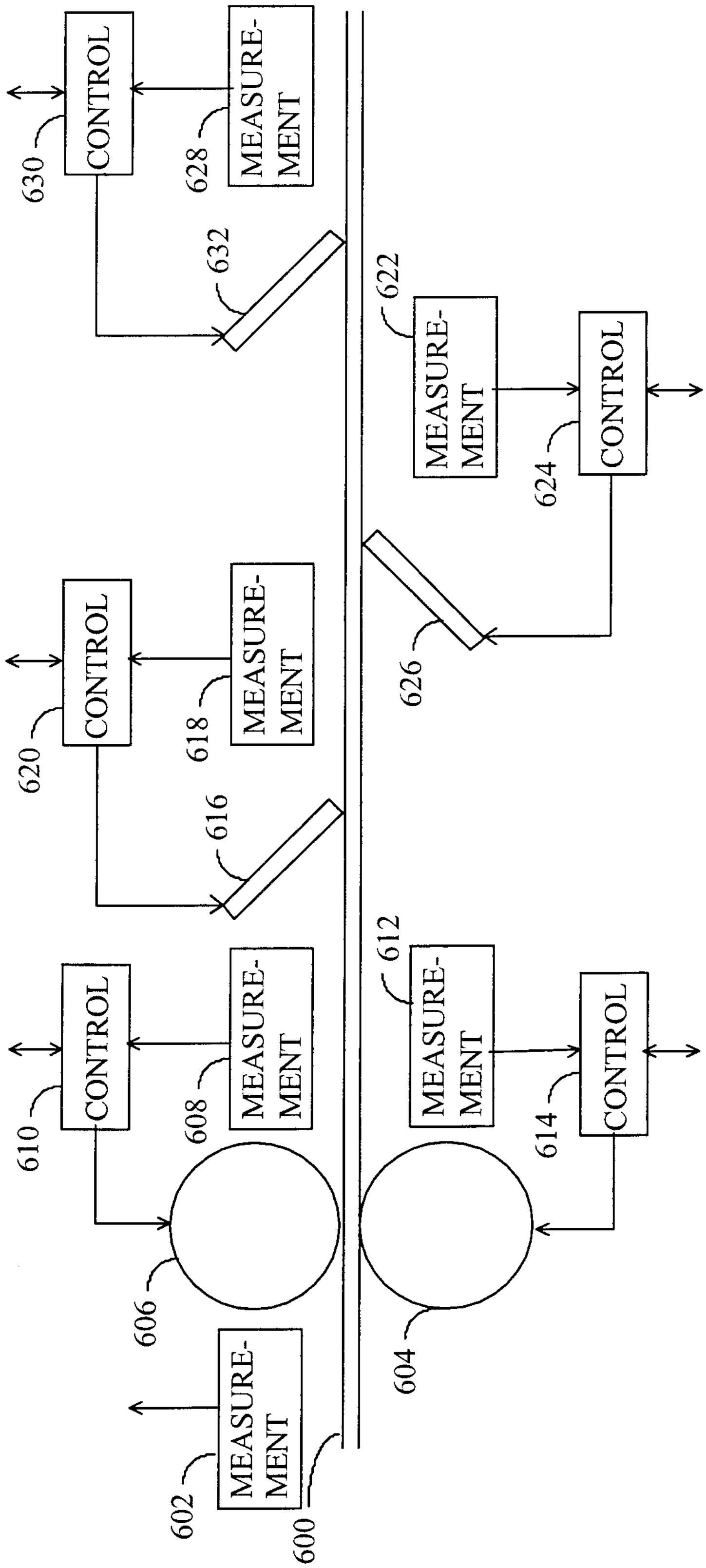
FIG. 5B

FIG. 5C

FIG. 5D

FIG. 5E

FIG. 5F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626
616
610
CONTROL
608
MEASURE-
MENT
612
MEASURE-
MENT
614
CONTROL
606
604
602
MEASURE-
MENT
600

FIG. 6

REFERENCES CITED IN THE DESCRIPTION

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